PSNN-2014-0870

Safety-Related

Toshiba Project Document No.	Rev. No.
FC51-7513-1002	2

Document filing No.	Rev. No.
RS-5183527	1

NRW-FPGA-Based I&C System Qualification Project

Electrical, Instrumentation & Control Test Report

Title: Software Validation Test Report

Customer Name	None
Project Name	NRW-FPGA-Based I&C System Qualification Project
Item Name	OPRM Equipment
Item Number	C51
Job Number	9P04482
Applicable Plant	None

Project	: NRW-FPGA-Based I&C system Qualification Project	
Contract No.	: ---	
	For Approval:	X For Information
Action		
A		Approved No Further Action
C		Approved with Comment Revised and Resubmit
D		Disapproved Revised and Resubmit
I	X	Accepted for Information Only ☐ Recommendation Included
Group	Instrumentation & Control Systems Design and Engineering Dept.	
Approved by		Reviewed by
T.Ito Aug.26,2014		T. Hayashi Aug. 26, 2014

Approval by buyer does not release seller of his obligation to furnish all goods and services in strict conformance with all of the terms of the Purchase Order.

TOSHIBA CORPORATION
NED

Rev.	Issue Date	Description	Approved by	Reviewed by	Prepared by
2	Feb. 19, 2014	See DECN- FC51-7513-1002-02	H. Kitazono Feb. 19, 2014	H. Kitazono Feb. 19, 2014	K. Kasai Feb. 19. 2014

Initial Issue Date	Issued by	Approved by	Reviewed by	Prepared by	Document filing No.
Nov.11, 2012	Nuclear Instrumentation & Control Systems Department	H.Kitazono Nov.11, 2012	H.Kitazono Nov.11, 2012	K. Kasai Nov.11, 2012	5B8K0093

Record of Revisions

Rev No.	Date	Description	Approved by	Reviewed by	Prepared by
0	See Cover Page	Initial Issue	See Cover Page	See Cover Page	See Cover Page
1	Apr.5 ,2013	See DECN- FC51-7513-1002-01	H.Kitazono Apr.5 ,2013	H.Kitazono Apr.5 ,2013	K. Kasai Apr.4 ,2013
2	See Cover Page	See DECN- FC51-7513-1002-02	See Cover Page	See Cover Page	See Cover Page

Table of Contents

1. Purpose

The purpose of this Software Validation Test Report is to report the result of the software validation test conducted in the system validation testing of the Oscillation Power Range Monitor (OPRM) for the NRW-FPGA-Based I&C System Qualification Project.

After the issuance of Revision 0 of this report, the design change of the OPRM unit, which led the design change of the TRN module and RCV module, was implemented to add a Cyclic Redundancy Check (CRC) function required in Revision 6 of the System Design Description (SDD) (Reference (24)) issued by Nuclear Energy Systems & Services Division (NED). After that, NED issued Revision 7 of the SDD to add a performance requirement related to the response time of trip signal generation, and issued the revision of the procurement specification (Reference (23)) specifying special conditions and parameters for an additional system validation testing. In response to requirements change in the SDD, the Equipment Design Specification (EDS) (Reference (4)) and the OPRM Unit Detailed Design Specification (DDS) (Reference (5)) were revised.

Thus, this report was revised to document the result of the software validation test conducted in the additional system validation testing.

The Nuclear Instrumentation & Control Systems Department (NICSD) Independent Verification and Validation (IV&V) Team prepared this report in accordance with test documentation requirements required in the NICSD V&V Plan (Reference (1)), the Master Test Plan (Reference (2)), and the Software Test Plan (Reference (3)) using NQ-3016 "Software Test" (Reference (12)) as a guide.

2. Scope

The scope of the test to be reported is the software validation tests conducted in the system validation testing and the additional system validation testing of the OPRM for the NRW-FPGA-Based I&C System Qualification Project.

The system validation testing was performed in accordance with the System Test Specification (Reference (6)) which included the special test for commercial grade items, factory acceptance testing (i.e., hardware test, prudency test, and operability test), and software validation test. Section 12 of the System Test Specification described the software validation test items, which referred to the Software Validation Test Plan (SVTP) (Reference (14)). The NICSD IV&V Team prepared the SVTP. The Test Personnel of the NICS-QC as the test engineers of the NICSD IV&V Team prepared the System Validation Test Procedure (Reference (15)) based on the System Test Specification and the SVTP. The Test Personnel executed the software validation test in accordance with Section 7.3 of the System Validation Test Procedure. The Test Personnel documented the system validation test result in the test record "System Validation Test for NRW-FPGA-Based I&C System Qualification Project" (herein after referred to as System Validation Test Record) (Reference (16)). The test result for the software validation test was provided in Section 4.3 of the System Validation Test Record.

The additional system validation testing was performed in accordance with the System Test Specification for Additional Validation (Reference (19)) which included the factory acceptance testing (i.e., hardware test), and software validation test. Section 10 of the System Test Specification for Additional Validation described the software validation test items, which referred to the SVTP for Additional Validation (Reference (20)). The NICSD IV&V Team prepared the SVTP for Additional Validation. The Test Personnel of the NICS-QC as the test engineers of the NICSD IV&V Team prepared the System Validation Test Procedure for Additional Validation (Reference (21)) based on the System Test Specification for Additional Validation and the SVTP for Additional Validation. The Test Personnel executed the software validation test in accordance with Section 7.2 of the System Validation Test Procedure for Additional Validation. The Test Personnel documented the system validation test result in the test record "System Validation Test for Additional Validation for NRW-FPGA-Based I&C System Qualification Project" (herein after referred to as System Validation Test Record for Additional Validation) (Reference (22)). The test result for the software validation test was provided in Section 3.2 of the System Validation Test Record for Additional Validation.

3. Applicable Documents

(1) Toshiba Project Document Number FA32-3709-1000
"Nuclear Instrumentation & Control Systems Department Verification and Validation Plan for FPGA-based Safety-Related Systems" Rev.6

(2) Toshiba Project Document Number FC51-7021-1000
"Master Test Plan for NRW-FPGA-Based I&C System Qualification Project" Rev.1

(3) Toshiba Project Document Number FA32-3705-1000
"Software Test Plan for FPGA-based Safety-Related Systems" Rev.0

(4) Toshiba Project Document Number FC51-3002-1000
"Equipment Design Specification for Power Range Neutron Monitor" Rev.4

(5) Toshiba Project Document Number FC51-3702-1000
"OPRM Unit Detailed Design Specification for Power Range Neutron Monitor" Rev.4

(6) Toshiba Project Document Number FC51-7101-1001
"Nuclear Instrumentation & Control Systems Department System Test Specification for Safety-Related Oscillation Power Range Monitor (OPRM)" Rev.6

(7) Toshiba Project Document Number FC51-8001-1000
"OPRM Unit User's Manual" Rev.4

(8) Toshiba Nuclear Instrumentation & Control Systems Department NQ-2003
"Procedure for Control of Software Tools" Rev.3

(9) Toshiba Nuclear Instrumentation & Control Systems Department NQ-2024
"Procedure for Document Control" Rev.8

(10) Toshiba Nuclear Instrumentation & Control Systems Department NQ-3011
"Qualification Procedure of Test Personnel and QC Inspector" Rev.5

(11) Toshiba Nuclear Instrumentation & Control Systems Department NQ-3015
"Test Control Procedure" Rev.5

(12) Toshiba Nuclear Instrumentation & Control Systems Department NQ-3016
"Software Test" Rev.4

(13) Toshiba Nuclear Instrumentation & Control Systems Department NQ-3017
"Measuring and Test Equipment Control Standard" Rev.6

(14) Toshiba Project Document Number FC51-7012-1003
"Software Validation Test Plan " Rev.3

(15) Toshiba Project Document Number FC51-7101-1000
"System Validation Test Procedure for NRW-FPGA-Based I&C System Qualification Project" Rev.3

(16) Toshiba Project Document Number FC51-7501-1001
"System Validation Test for NRW-FPGA-Based I&C System Qualification Project" (System Validation Test Record)

(17) Toshiba Nuclear Instrumentation & Control Systems Department 5B8K0072
"Evaluation Report for OPRM Test Tool" Rev.1

(18) Toshiba Nuclear Instrumentation & Control Systems Department FDS-JHS-000204
"Evaluation Report for Test Pattern Files" Rev.2

(19) Toshiba Project Document Number FC51-7101-1003
"Nuclear Instrumentation & Control Systems Department System Test Specification for Additional Validation for Safety-Related Oscillation Power Range Monitor (OPRM)" Rev.0

(20) Toshiba Project Document Number FC51-7012-1004
"Software Validation Test Plan for Additional Validation" Rev.0

(21) Toshiba Project Document Number FC51-7101-1004
"System Validation Test Procedure for Additional Validation for NRW-FPGA-Based I&C System Qualification Project" Rev.1

(22) Toshiba Project Document Number FC51-7501-1006
"System Validation Test for NRW-FPGA-Based I&C System Qualification Project" (System Validation Test Record for Additional Validation)

(23) Toshiba Project Document Number FC51-3601-0001
"Procurement Specification for Equipment Qualification and EMC Qualification of Components of Oscillation Power Range Monitor (OPRM)" Rev.11

(24) Toshiba Project Document Number FC51-1001-0001
"System Design Description for Neutron Monitoring System" Rev.8

4. Abbreviations

ABA	Amplitude Based detection Algorithm
AC	Alternate Current
APRM	Average Power Range Monitor
CI	Communication Interface
CRC	Cyclic Redundancy Check
DDS	Detailed Design Specification
EDS	Equipment Design Specification
ELCS	Engineered Safety Features Logic & Control System
FPGA	Field Programmable Gate Array
GRA	Growth Rate detection Algorithm
HMI	Human-Machine Interface
I&C	Instrumentation and Control
IV&V	Independent Verification and Validation
LED	Light Emitting Diode
LPRM	Local Power Range Monitor
M&TE	Measuring and Test Equipment
NED	Nuclear Energy Systems & Services Division
NISD	Nuclear Instrumentation Systems Development & Designing Group
NICSD	Nuclear Instrumentation & Control Systems Department
NICS-QC	Quality Control Group for Nuclear Instrumentation & Control Systems
NQ	Nuclear Quality
NRW	Non-Rewritable
OPRM	Oscillation Power Range Monitor
PBDA	Period Based Detection Algorithm
PFC	Power Factor Correction module [a, c]
QC	Quality Control
Sat.	Satisfactory
SDD	System Design Description
SOE	Sequence of Event
SVTP	Software Validation Test Plan
TDR	Transient Data Recorder

5. Test Description

5.1 Test System

The test system consists of test specimen, and test equipment. The test system configuration for the system validation testing is as shown in Figure 5-1. The same test system configuration as that used for the system validation testing was used for the additional system validation testing.

The test specimen consists of one OPRM unit with two Power Factor Correction modules (PFCs). The test specimen is mounted on a test specimen rack. The list of the test specimen for the system validation testing, and the additional system validation testing is shown in Table 5-1-1, and Table 5-1-2, respectively.

The test equipment mainly consists of [ ]a, c

A [ ]a, c optical transmit output. A [ ]a, c optical receive input. The [ ]a, c simulates one APRM unit. A redundant optical transmission input signal from the APRM unit is simulated by [ ]a, c. The [ ]a, c is used to simulate four LPRM units. One port of the [ ]a, c simulates optical transmission signals of one LPRM unit containing 13 LPRM Levels, which undergoes a transient change, and provides those signals to the OPRM unit.

The [ ]a, c monitors the optical transmission output signals from the OPRM unit. Since the optical transmission signals output from the OPRM unit to ELCS and [ ]a, c are equivalent, one typical port of those four ports on the TRN module (TRN1) in the OPRM unit is monitored with one port of the [ ]a, c. Since the optical signals output from the OPRM unit to SOE and TDR are equivalent, one typical port of those four ports on the TRN module (TRN2) in the OPRM unit is monitored with one port of the [ ]a, c.

The relay unit is simulated by the aux-relay plate which uses general mechanical relays. Discrete output signals from the OPRM unit are monitored with the data recorder via the aux-relay plate. A discrete input signal (i.e., APRM bypass signal) is provided to the OPRM unit via the aux-relay plate.

The OPRM unit is powered from two redundant Class 1E AC power supplies. Both of those AC power supplies provide nominal 120 VAC, 60 Hz power. Fuses, varistors, and noise filters equivalent to actual products are inserted to the power lines in the test specimen rack. These fuses, varistors, and noise filters are dealt as test equipment not as test specimen.

The list of the test support equipment and Measuring and Test Equipment (M&TE) used for the system validation testing, and the additional system validation testing is shown in Table 5-2-1, and Table 5-2-2, respectively.

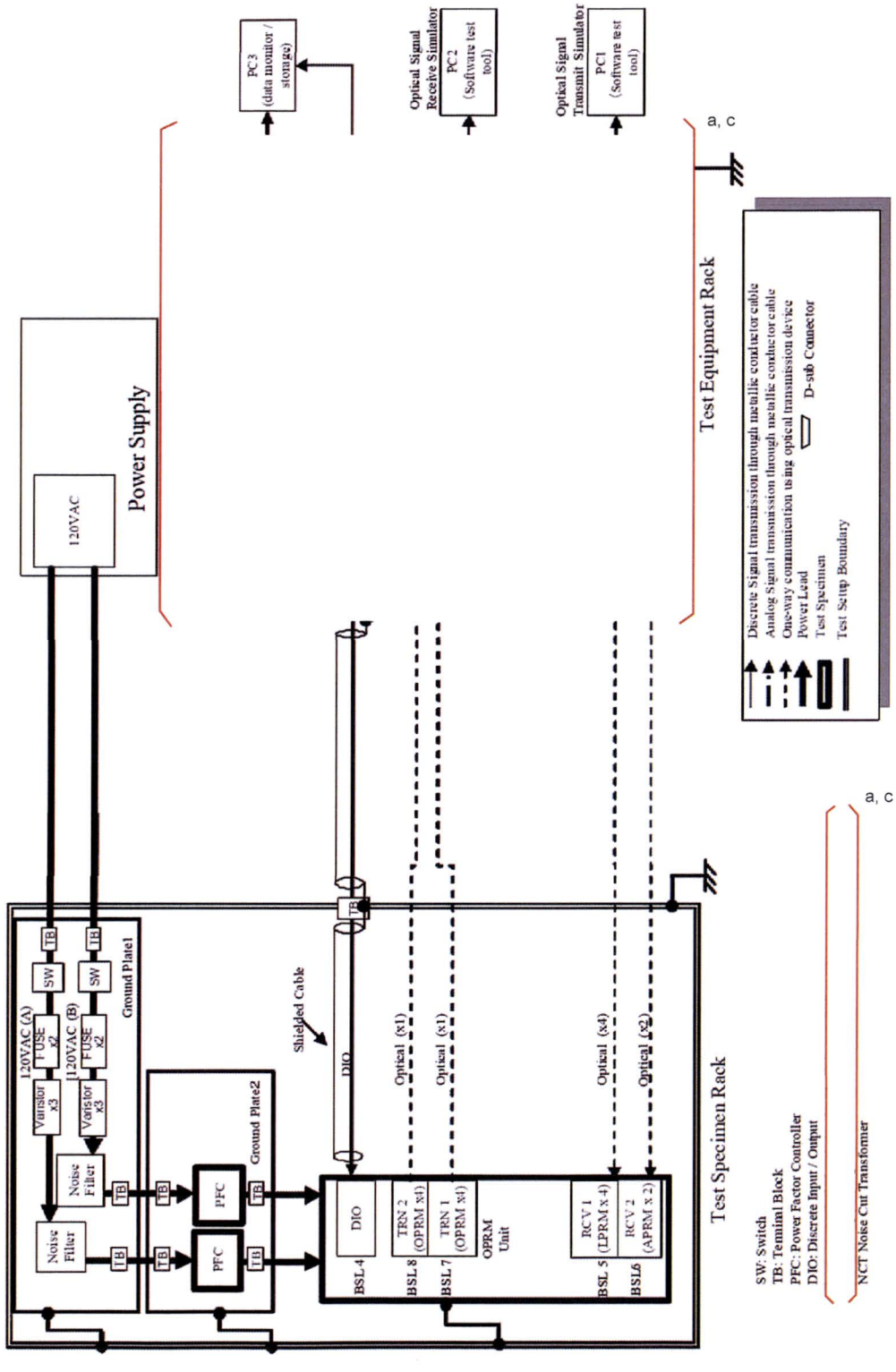


Figure 5-1 Test System

5.2 List of Test Specimen

The following table shows the list of the test specimen used for the system validation testing excerpted from the System Validation Test Record (Reference (16)).

Table 5-1-1 List of Test Specimen

Description	Slot ID (Instrument Number)	Model Number	Serial Number	Qty	Judgment
☑OPRM Unit	–	☑HNU1200B00000	☑10920017	☑1	Sat.
☑OPRM Chassis	–	☑22890-375	☑5312101000/AA	☑1	Sat.
☑CELL Module	FSL 5 to 7	☑HNS0400B00000	☑1206818335	☑1	Sat.
☑AGRD Module	FSL 8 to 9	☑HNS0420B00000	☑1206818331	☑1	Sat.
☑PBD Module	FSL 10 to 11	☑HNS0430B00000	☑1206818312	☑1	Sat.
☑DAT/ST Module	FSL 14	☑HNS0410B00000	☑1206818322	☑1	Sat.
☑LVPS Module	PSSL1	☑HNS0500B00000	☑1282858	☑2	Sat.
	PSSL2	☑HNS0500B00000	☑1282859		Sat
☑DIO Module	BSL4	☑HNS0520B00000	☑1202803706	☑1	Sat.
☑TRN Module	BSL7	☑HNS0531B00000	☑1206818325	☑2	sat.
	BSL8	☑HNS0531B00000	☑1206818326		sat.
☑RCV Module	BSL5	☑HNS0541B00000	☑1206818316	☑2	Sat.
	BSL6	☑HNS0541B00000	☑1206818317		Sat.
☑PFC	(PFC1)	☑BPC-10	☑1252373	☑2	Sat.
	(PFC2)	☑BPC-10	☑1252374		Sat.

The following table shows the list of the test specimen used for the additional system validation testing excerpted from the System Validation Test Record for Additional Validation (Reference (22)).

Table 5-1-2 List of Test Specimen (for Additional System Validation Testing)

Description	Slot ID (Instrument Number)	Model Number	Serial Number	Qty	Judgment
☑OPRM Unit	–	☑HNU1200B00000 Feb.7,2014 K.Ohnda	☑10920017	☑1	Sat.
☑OPRM Chassis	–	☑22890-375	☑5312101000/AA	☑1	Sat.
☑CELL Module	FSL 5 to 7	☑HNS0400B00000	☑1206818335	☑1	Sat.
☑AGRD Module	FSL 8 to 9	☑HNS0420B00000	☑1206818331	☑1	Sat.
☑PBD Module	FSL 10 to 11	☑HNS0430B00000	☑1206818312	☑1	Sat.
☑DAT/ST Module	FSL 14	☑HNS0410B00000	☑1206818322	☑1	Sat.
☑LVPS Module	PSSL1	☑HNS0500B00000	☑1282858	☑2	Sat.
	PSSL2	☑HNS0500B00000	☑1282859		Sat.
☑DIO Module	BSL4	☑HNS0520B00000	☑1202803706	☑1	Sat.
☑TRN Module	BSL7	☑HNS0531B00001	☑1212828256	☑2	Sat.
	BSL8	☑HNS0531B00001	☑1212828257		Sat.
☑RCV Module	BSL5	☑HNS0541B00001	☑1212828262	☑2	Sat.
	BSL6	☑HNS0541B00001	☑1212828263		Sat.
☑PFC	(PFC1)	☑BPC-10	☑1252373	☑2	Sat.
	(PFC2)	☑BPC-10	☑1252374		Sat.

5.3 List of Test Support Equipment and Measuring and Test Equipment

The following table shows the list of the test support equipment and the Measuring and Test Equipment (M&TE) used for the system validation testing excerpted from the System Validation Test Record (Reference (16)). The NICSD IV&V Team confirmed that those M&TE were controlled in accordance with NQ-3017 "Measuring and Test Equipment Control Standard" (Reference (13)).

Table 5-2-1 List of Test Support Equipment and Measuring and Test Equipment List (1/2)

No.	*Item Description*	*Manufacturer/ Model #*	*Serial# / Control #*	*Cal. date (YY/MM/DD)*	*Cal. Due (YY/MM/DD)*
1	Caliper			12/08/17	13/07/31
2	Non-automatic electronic weighing instrument			12/08/09	13/07/31
3	Insulation Resistance Tester			12/08/06	13/07/31
4	Withstanding Voltage Tester			12/08/03	13/01/31
5	Digital Multimeter			12/08/01	13/07/31
6	Clamp On AC/DC Hitester			12/07/31	13/07/31
7	Scope Corder			12/07/30	13/07/31
	Intentionally left blank				

Note) *1 Test Support Equipment

Table 5-2-1 List of Test Support Equipment and Measuring and Test Equipment List (2/2)

No.		*Item Description*	*Manufacturer/ Model #*	*Serial# / Control #* a, c	*Cal. date (YY/MM/DD)*	*Cal. Due (YY/MM/DD)*
8	*1	Inrush Current Measurement Device			12/03/07	13/02/28
9	*1	AC Power Supply			12/07/24	13/07/31
10	*1	Optical Signal Transmit Simulator(OSTS)	Toshiba / None	None /FDTR-12-0001 /FDTR-12-0002	N/A Pre-operation inspection	
11	*1	Optical Signal Recive Simulator(OSRS)	Toshiba / None	None /FDTR-12-0001 a, c		
12	*1	Data Logger (LOGGER)			11/05/25	13/05/31
13	*1	Thermo/Hygrometer			12/07/30	13/07/31
		Intentionally left blank				

Note) *1 Test Support Equipment

The following table shows the list of the test support equipment and the M&TE used for the additional system validation testing excerpted from the System Validation Test Record for Additional Validation (Reference (22)). The NICSD IV&V Team confirmed that those M&TE were controlled in accordance with NQ-3017 "Measuring and Test Equipment Control Standard" (Reference (13)).

Table 5-2-2 List of Test Support Equipment and Measuring and Test Equipment List for Additional System Validation Testing (1/2)

No.	*Item Description*	*Manufacturer/ Model #*	*Serial# / Control #*	*Cal. date (YY/MM/DD)*	*Cal. Due (YY/MM/DD)*
1	Digital Multimeter			a, c 12/08/01	13/07/31
2	Clamp On AC/DC Hitester			12/07/31	13/07/31
3	Scope Corder			12/07/30	13/07/31
	Intentionally left blank				

Note) *1 Test Support Equipment

Table 5-2-2 List of Test Support Equipment and Measuring and Test Equipment List for Additional System Validation Testing (2/2)

No.	Item Description	Manufacturer/ Model #	Serial# / Control # a, c	Cal. date (YY/MM/DD)	Cal. Due (YY/MM/DD)
4	*1 AC Power Supply			12/07/24	13/07/31
5	*1 Optical Signal Transmit Simulator(OSTS)	Toshiba / None	None /FDTR-12-0005 /FDTR-12-0006	N/A Pre-operation inspection	
6	*1 Optical Signal Recive Simulator(OSRS)	Toshiba / None	None /FDTR-12-0005 a, c		
7	*1 Data Logger (LOGGER)			11/05/25	13/05/31
	Intentionally left blank				

Note) *1 Test Support Equipment

5.4 Test Personnel Identification

The manager of Quality Control Group for Nuclear Instrumentation & Control Systems (NICS-QC) was responsible for execution of system validation testing in accordance with NQ-3015 "Test Control Procedure" (Reference (11)). The manager of NICS-QC was also responsible for assigning a "Test Personnel" qualified in accordance with NQ-3011 "Qualification Procedure of Test Personnel and QC Inspector" (Reference (10)) as a tester for system validation testing.

Figure 5-2 shows the manager of NICS-QC and the Test Personnel who involved in the system validation testing, and the additional system validation testing.

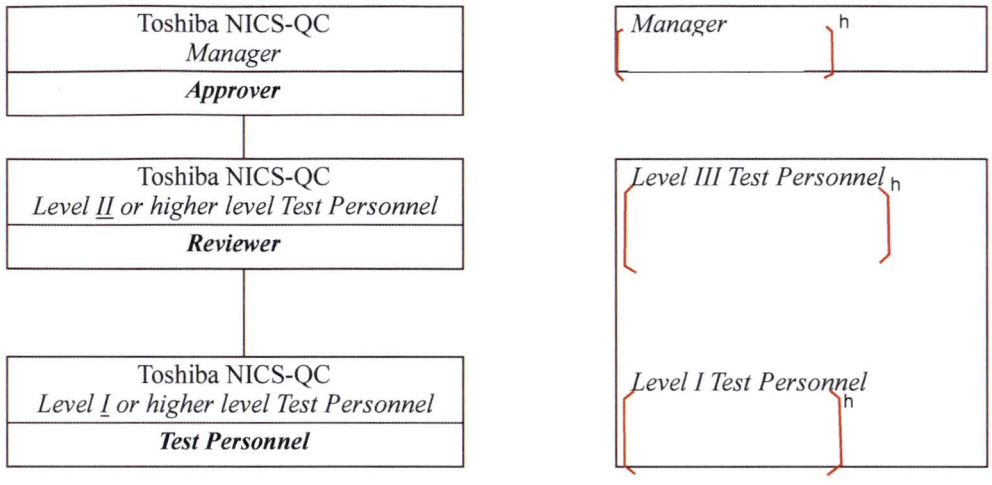


Figure 5-2 Test Personnel Identification

6. Evaluation of Test Equipment Software

6.1 Test Equipment Software Identification

The NISD controlled the test equipment software listed in Table 6-1-1 used for the software validation test for the system validation testing, and the test equipment software listed in Table 6-1-2 used for the software validation test for the additional system validation testing. The NICSD IV&V Team confirmed that NISD appropriately performed the configuration control of the test equipment software in accordance with NQ-2003 "Procedure for Control of Software Tools" (Reference (8)) using the Software Tool Registration Application Form listed in Table 6-1-1 and Table 6-1-2.

Table 6-1-1 List of Test Equipment Software

Tool Type	Software Tool Registration Application Form Number	Version
OPRM Test Tool (Optical Signal Receive Simulator, Optical Signal Transmit Simulator)	FDTR-12-0001-KM	NYP134・01-001-C
OPRM Test Pattern Files	FDTR-12-0002-KM	NZH002・00-001-C

Table 6-1-2 List of Test Equipment Software for Additional System Validation Testing

Tool Type	Software Tool Registration Application Form Number	Version
OPRM Test Tool (Optical Signal Receive Simulator, Optical Signal Transmit Simulator)	FDTR-12-0005-KM	NYP134・04-001-C
OPRM Test Pattern Files	FDTR-12-0006-KM	NZH002・01-001-C

6.2 Evaluation of OPRM Test Tool

The OPRM Test Tool included the Optical Signal Receive Simulator and Optical Signal Transmit Simulator.

The Optical Receive Simulator comprised of the [ ]^{a,c} module (called the [ ]^{a,c} in Figure 5-1) contained in PCI Bus Expansion Chassis (called the PCI Ex-Box 2 in Figure 5-1) and PC (called the PC2 in Figure 5-1).

The Optical Transmit Simulator comprised of the [ ]^{a,c} (called the [ ]^{a,c} in Figure 5-1) contained in PCI Bus Expansion Chassis (called the PCI Ex-Box 1 in Figure 5-1) and PC (called the PC1 in Figure 5-1).

Test Personnel from the NICS-QC tested the OPRM Test Tool in accordance with the test specification prepared by a tool developer from NISD, and recorded their results in test record. NICSD performed the test outside this project scope. The NICSD IV&V Team reviewed the test documents for the OPRM Test Tool listed in Table 6-2-1 and Table 6-2-2, and confirmed that test was performed in accordance with the test specification, and all test results were acceptable.

Table 6-2-1 List of Test Documents for OPRM Test Tool

Tool Type	Document No.	Rev.
Test Specification for OPRM Unit Test Tool (Optical Signal Receive Simulator/Optical Signal Transmit Simulator)	5T8H7766	2
Test Record for Optical Signal Receive Simulator/Optical Signal Transmit Simulator	ATC-103723	-

Table 6-2-2 List of Test Documents for OPRM Test Tool for Additional System Validation Testing

Tool Type	Document No.	Rev.
Test Specification for OPRM Unit Test Tool (Optical Signal Receive Simulator/Optical Signal Transmit Simulator) (CRC)	5T8H7829	1
Test Record for Optical Signal Receive Simulator/Optical Signal Transmit Simulator (CRC)	ATC-104150	-

6.3 Generation of LPRM levels for Input Test Pattern

A LPRM level input is simulated with the following basic equation.

a, c

Based on the above basic equation, four LPRM levels comprising an OPRM Cell (i.e., y_A: LPRM A, y_B: LPRM B, y_C: LPRM C, and y_D: LPRM D) can be further defined as follows.

a, c

The NICSD IV&V Team generated input test patterns of LPRM levels using above equation with test pattern generation tool. This equation can simulate various types of oscillation signals by changing the parameters.

If all the LPRM levels in a Cell synchronize, the Normalized Oscillation Signal (St) simulated by the theoretical

formula may be simplified with a filtered single LPRM level except noise as follows.

Normalized Oscillation Signal (St):

$$St = \text{a, c}$$

a, c

Based on the functionality of the OPRM unit, the NICSD IV&V Team determined expected output for each input test pattern as responses of OPRM unit to the simulated Normalized Oscillation Signal (St) and other input parameter conditions.

6.4 Evaluation of Test Pattern Generation Tool

A tool developer from NISD compared the following 3 types of calculation results to validate the test pattern generation tool:

- Normalized Oscillation Signal obtained through desktop calculations with the theoretical formula shown above,
- Normalized Oscillation Signal calculated by the OPRM unit which was obtained by inputting a typical oscillation waveform generated with the test pattern generation tool into the OPRM unit, and
- Normalized Oscillation Signal calculated by means of versatile software Octave (GNU Octave, version 3.2.4) as alternative calculation method.

The tool developer from NISD documented the results of the validation in the "Evaluation Report for OPRM Test Tool" (Reference (17)). The NICSD IV&V Team reviewed this document and confirmed that it was acceptable to use the test pattern generation tool in creating test patterns for the OPRM test.

6.5 Evaluation of Test Pattern Files

Using the test pattern generation tool as above, the NICSD IV&V Team created individual test patterns to be used for the software validation testing of the OPRM unit, fed those test patterns in the OPRM unit with the Optical Signal Transmit Simulator, and collected Normalized Oscillation Signals calculated by the OPRM unit with the Optical Signal Receive Simulator.

The NICSD IV&V Team made a comparison of calculation results between the Normalized Oscillation Signal calculated by the OPRM unit and the Normalized Oscillation Signal manually calculated with the versatile software Octave as alternative calculation method to evaluate whether those test patterns would conform to the test purpose. The NICSD IV&V Team documented the results of the evaluation in the "Evaluation Report for Test Pattern Files" (Reference (18)). Thus the NICSD IV&V Team confirmed that it would be acceptable to use the test patterns file created with the test pattern generation tool in performing the software validation test.

7. Test Items for Software Validation Test

Software validation testing in the system validation testing for OPRM was performed to ensure that the integrated software meets the requirements stated in the Equipment Design Specification (EDS) (Reference (4)) and the OPRM Unit Detailed Design Specification (DDS) (Reference (5)). The basic concepts to determine test items and test patterns for this software validation test were described in Section 9 of the SVTP (Reference (14)). Table 7-1-1 shows the test items for the software validation test and references to corresponding sections of the System Validation Test Report and System Validation Test Record (Reference (16)).

Table 7-1-1 List of Test Items

Test Item	Section No. in Software Validation Test Report	Section No. in System Validation Test Record
Standard Setting Check (Initial Setpoint)	8.1	4.3.1
Normalized Oscillation Signal Processing	8.2	4.3.2
Normalized Oscillation Signal Processing (without LPRM bypass)	8.2.1	4.3.2.1
Normalized Oscillation Signal Processing (with LPRM bypass)	8.2.2	4.3.2.2
OPRM Region Determination (OPRM Automatic Bypass)	8.3	4.3.3
Trip Determination Functions	8.4	4.3.4
Amplitude-Based Maximum Trip (ABA Trip) Determination	8.4.1	4.3.4.1
Growth Rate-Based Trip (GRA Trip) Determination	8.4.2	4.3.4.2
Period-Based Trip (PBDA Trip) Determination	8.4.3	4.3.4.3
Trip Algorithm Initialization	8.4.4	4.3.4.4
Failure Detection and Self Diagnosis Functions	8.5	4.3.5
OPRM Inoperative	8.5.1	4.3.5.1
OPRM Minor Failure	8.5.2	4.3.5.2
Other Functions	8.6	4.3.6
Test Functions	8.6.1	4.3.6.1
Discrete Input Signal Toggling	8.6.2	4.3.6.2
Optical Transmission Integrity Test	8.6.3	4.3.6.3
Random HMI Operation	8.6.4	4.3.6.4
Initialization	8.6.5	4.3.6.5

Software validation testing in the additional system validation testing was performed:

- To demonstrate that CRC functions added to the OPRM unit are correctly implemented and functions as intended.
- To demonstrate that the OPRM unit performs its safety functions under specific conditions specified by NED with additional performance requirements for the OPRM Trip response time of the OPRM unit.

Test items are configured based on the CRC functions and additional requirements stated in the EDS (Reference (4)), the OPRM Unit DDS (Reference (5)) and the procurement specification (Reference (23)). The rationale for determination of the test items and test patterns for this software validation test in the additional system validation testing were described in Section 9 of the SVTP for Additional Validation (Reference (20)). Table 7-1-2 shows the test items for the software validation test and references to corresponding sections of the System Validation Test Report for Additional Validation and System Validation Test Record for Additional Validation (Reference (22)).

Table 7-2-2 List of Test Items
for Additional System Validation Testing

Test Item	Section No. in Software Validation Test Report for Additional Validation	Section No. in System Validation Test Record for Additional Validation
Standard Setting Check (Initial Setpoint)	10.1	3.2.1
CRC Function	10.2	3.2.2
Additional Validation of Trip Algorithms	10.3	3.2.3

8. Test Results

The Test Personnel performed the software validation test in October 2012 in accordance with the approved System Validation Test Procedure (Reference (15)), and documented the test result in the System Validation Test Record. The System Validation Test Record was approved by the manager of NICS-QC.

The following subsections described the test result for each test item. The test results referenced in the following subsections were excerpted from the System Validation Test Record (Reference (16)).

In the following subsections, the test result of each item was reported using the following paragraphs.

(1) Explanation of Test Item

This paragraph explained the overview of each test item. For detailed test steps and acceptance criteria, refer to the SVTP (Reference (14)).

(2) Test Result

This paragraph shows the excerpted test result from the System Validation Test Record. Although test results included the record for setting prior to each test item, or test record for recovery check after the each test item, the NICSD IV&V Team only excerpted the test result that showed the significant test result demonstrating the function of the OPRM unit tested. If the test item included multiple test steps following multiple test results, the NICSD IV&V Team selected a representative step to show the typical test result, as appropriate. For all the detailed test result, refer to the System Validation Test Record (Reference (16)).

8.1 Standard Setting Check (Initial Setpoint)

(1) Explanation of Test Item

The parameter setting and jumper pin setting specified the SVTP were used as "Standard Settings" for software validation testing. It was checked that the parameters displayed on the module front panel were consistent with the values specified in "Standard Settings."

(2) Test Result

Form Ns : Normal Status(Operation) (3 of 8) **Step No.** 4.3.1 9)

2. Confiramation of "Standard Setting" of OPRM unit Operation)

CELL Module Parameter				Judgment
PARMETER 1	PARMETER 2	Result		
1	Time Average Filter Cut-off Frequency Setpoint	☑	0.167	Sat.
2	LPRM Lower-limit Setpoint	☑	5.0	
3	Conditioning Filter Cut-off Frequency Setpoint	☑	1.000	
4	Minimum Number of Active OPRM Cell Setpoint	☑	32	
5	OPRM Region APRM Level Setpoint	☑	30.0	
6	OPRM Region Core Flow Level Setpoint	☑	60.0	
7	OPRM Region APRM Level Hysteresis Setpoint	☑	1	
8	OPRM Region Core Flow Level Hysteresis Setpoint	☑	1	
9	Minimum Number of Active LPRMs	☑	2	

AGRD Module Parameter				Judgment
PARMETER 1	PARMETER 2	Result		
1	Threshold Setpoint (S1)	☑	1.10	Sat.
2	Minimum Threshold Setpoint (S2)	☑	0.92	
3	Growth Rate Factor (DR3)	☑	1.30	
4	Maximum Amplitude Trip Setpoint (Smax)	☑	1.30	
5	Growth Amplitude Setpoint(S3)	N/A		
6	Time Window for Minimum Threshold Setpoint (TI)	☑	0.31	
7	Time Window for Trip Setpoint (Th)	☑	2.20	a, c
8	ABA and GRA Trip Hold Time Setpoint (Ttph)	☑	[ ]	
9	Peak and Valley Detection Width Setpoint (a) (Note 1)	☑	0.003	

Note 1: This parameter is shown as 1 to 10 on the numerical display of the AGRD module.

PBD Module Parameter				Judgment
PARMETER 1	PARMETER 2	Result		
1	Period Minimum Setpoint (Tmin)	☑	1.00	Sat.
2	Period Maximum Setpoint (Tmax)	☑	3.50	
3	Period Tolerance Setpoint (Te)	☑	0.150	
4	Confirmation Count Trip Setpoint (Np)	☑	10	
5	PBDA Amplitude Trip Setpoint (Sp)	☑	1.10	a, c
6	PBDA Trip Hold Time Setpoint (Ttph)	☑	[ ]	
7	Peak and Valley Detection Width Setpoint(a) (Note 2)	☑	0.003	

Note 2: This parameter is shown as 1 to 10 on the numerical display of the PBD module.

Result		Acceptance Criteria	Judgment
Item	Status		
"Standard Setting" of OPRM unit	See above	See above	Sat.

8.2 Normalized Oscillation Signal Processing

In the following test items, functionality of Normalized Oscillation Signal Processing depending on parameters and conditions specified in each test item was tested.

8.2.1 Normalized Oscillation Signal Processing (without LPRM Bypass)

The purpose of this test item is to check that the Normalized Oscillation Signal calculation is performed under normal state (i.e., calculation is performed with no LPRM Levels bypassed) by inputting a simulated signal of LPRM units in the OPRM unit.

1. Test Pattern 1

(1) Explanation of Test Item

This test pattern input a sine curve as LPRM Levels of 52ch that make up 44 Cells. Using this test pattern, it was checked that filtering process, time average process, and normalization are executed for each cell and Normalized Oscillation Signals were calculated as expected.

(2) Test Result

T_{PHASE} T_{L_PEAK}; Determine peak position of Peak 10 of LPRM Level 1 T_{N_PEAK}; Determine peak position of Peak 10 of Nprmalized Oscillation Signal (St) of CELL 1				
Result (PC data)			Acceptance Criteria (S)	Judgment a, c
T_{N_PEAK} (s)	T_{L_PEAK} (s)	T_{PHASE} (s)		
				Sat.

2. Test Pattern 2

(1) Explanation of Test Item

In this test pattern, CELL 9 was selected to change 4 LPRM values included in CELL9 one by one from the state that a constant value had been set. It was checked that Normalized Oscillation Signal change as expected by averaging process.

(2) Test Result

☑Check the Normalized Oscillation Signals (St) of CELL 9 at following Peak							
Result(ELCS) a, c		Acceptance Criteria	Judgment a, c	Result(ELCS) a, c		Acceptance Criteria	Judgment a, c
Peak	T_{N_PEAK}			Peak	T_{N_PEAK}		
8			Sat.	24			Sat.
16			Sat.	32			Sat.

3. Test Pattern 3

(1) Explanation of Test Item

In this test pattern, constant LPRM values as LPRM Levels of 52ch that make up 44 Cells were input. After the elapse of a certain period of time, it was checked that Normalized Oscillation Signals in the CELL module indication turned to 1 and that Filtered Flux had the value expected.

(2) Test Result

☑Check the Normalized Oscillation Signals (St) of CELL 1 through CELL 44

Result(CELL module) CELL No.	NOS	Acceptance Criteria	Judgment a, c	Result(CELL module) CELL No.	NOS	Acceptance Criteria	Judgment a, c
1			Sat.	23			Sat.
2			Sat.	24			Sat.
3			Sat.	25			Sat.
4			Sat.	26			Sat.
5			Sat.	27			Sat.
6			Sat.	28			Sat.
7			Sat.	29			Sat.
8			Sat.	30			Sat.
9			Sat.	31			Sat.
10			Sat.	32			Sat.
11			Sat.	33			Sat.
12			Sat.	34			Sat.
13			Sat.	35			Sat.
14			Sat.	36			Sat.
15			Sat.	37			Sat.
16			Sat.	38			Sat.
17			Sat.	39			Sat.
18			Sat.	40			Sat.
19			Sat.	41			Sat.
20			Sat.	42			Sat.
21			Sat.	43			Sat.
22			Sat.	44			Sat.

☑Check the Filtered Flux of CELL 1 through CELL 22

CELL No.	Result(CELL module) BYP (UL)	BYP (UR)	BYP (LL)	BYP (LR)	Acceptance Criteria a, c	Judgment
1						Sat.
2						Sat.
3						Sat.
4						Sat.
5						Sat.
6						Sat.
7						Sat.
8						Sat.
9						Sat.
10						Sat.
11						Sat.
12						Sat.
13						Sat.
14						Sat.
15						Sat.
16						Sat.
17						Sat.
18						Sat.
19						Sat.
20						Sat.
21						Sat.
22						Sat.

4. Test Pattern 4

(1) Explanation of Test Item

In this test pattern, CELL 10 was selected as a representative to check the filtering initialization function (i.e., Normalized Oscillation Signal value became 1.) when the Number of Active LPRMs changed (i.e., LPRM bypass occurred.) due to the following conditions.

- LPRM Level is less than the LPRM Lower-limit Setpoint.
- When inoperative (bypass) occurs in the LPRM unit.
- When a transmission error occurs in the LPRM unit.

(2) Test Result

☑Check that the Normalized Oscillation Signals (St) of CELL 10 in the period of following Peak once resets, and oscillates again.

Result(ELCS/PICS)		Acceptance Criteria	Judgment a, c	Result(ELCS/PICS)		Acceptance Criteria	Judgment a, c
Peak	T N_PEAK			Peak	T N_PEAK		
8			Sat.	24			Sat.
16			Sat.	32			Sat.

5. Test Pattern 5

(1) Explanation of Test Item

In this test pattern, CELL 11 was selected as a representative to check that the Levels meeting the following conditions (i.e. LPRM bypass occurs.) were excluded from the calculation of Averaged Flux.

- LPRM Level is less than the LPRM Lower-limit Setpoint.
- When inoperative (bypass) occurs in the LPRM unit.
- When a transmission error occurs in the LPRM unit.

(2) Test Result

☑Check the Normalized Oscillation Signals (St) of CELL 11 at following Peak

Result(ELCS/PICS)		Acceptance Criteria	Judgment	Result(ELCS/PICS)		Acceptance Criteria	Judgment
Peak	T N_PEAK		a, c	Peak	T N_PEAK		a, c
8			Sat.	40			Sat.
16			Sat.	48			Sat.
24			Sat.	56			Sat.
32			Sat.	64			Sat.

8.2.2 Normalized Oscillation Signal Processing (with LPRM bypass)

(1) Explanation of Test Item

In this test, it was checked that the Normalized Oscillation Signal calculation was performed under abnormal state

(i.e., calculation was performed with certain number of LPRM Levels bypassed) by inputting a simulated abnormal signal of LPRM units.

(2) Test Result

4.3.2.2.1 Step1 ("Normal")

☑1) Check that status of module display is as acceptance criteria in the table below.

Expected Output of "BYP" LEDs on CELL module

Cell No.	BYP (UL)	BYP (UR)	BYP (LL)	BYP (LR)	Cell No.	BYP (UL)	BYP (UR)	BYP (LL)	BYP (LR)
	LPRM CH in Division					LPRM CH in Division			
☑1	-	1	3	41	☑23	32	45	8	21
☑2	1	14	41	28	☑24	45	7	21	35
☑3	14	27	28	15	☑25	7	20	35	48
☑4	27	40	15	4	☑26	20	33	48	9
☑5	40	2	4	42	☑27	33	46	9	22
☑6	2	-	42	29	☑28	34	47	-	10
☑7	-	3	43	30	☑29	47	8	10	49
☑8	3	41	30	16	☑30	8	21	49	36
☑9	41	28	16	5	☑31	21	35	36	23
☑10	28	15	5	44	☑32	35	48	23	11
☑11	15	4	44	31	☑33	48	9	11	50
☑12	4	42	31	17	☑34	9	22	50	37
☑13	42	29	17	6	☐35	10	49	38	24
☐14	43	30	18	19	☑36	49	36	24	12
☑15	30	16	19	32	☑37	36	23	12	51
☑16	16	5	32	45	☑38	23	11	51	39
☐17	5	44	45	7	☑39	11	50	39	25
☐18	44	31	7	20	☐40	50	37	25	-
☐19	31	17	20	33	☑41	24	12	-	52
☑20	17	6	33	46	☑42	12	51	52	13
☑21	18	19	34	47	☑43	51	39	13	26
☐22	19	32	47	8	☑44	39	25	26	-

Hatched portion "▨" of "BYP (UL)," "BYP (UR)," "BYP (LL)," and "BYP (LR)" columns means that corresponding LED turns ON. Hatched portion "▨" of "Cell No. column means that corresponding CELL is bypassed.

Result(CELL module) LED	Result(CELL module) Status	Acceptance Criteria	Judgment	Result(CELL module) "Amp/%/Cunt"	Result(CELL module) Status	Acceptance Criteria	Judgment
"BYP" (LPRM Bypass)	See above	See above	Sat.	"CELL Conunt"	44	44	Sat.

Result(CELL module) LED	Result(CELL module) Status	Acceptance Criteria	Judgment	Result(CELL module) "Amp/%/Cunt"	Result(CELL module) Status	Acceptance Criteria	Judgment
"BYP" (LPRM Bypass)	See above	See above	Sat.	"CELL Conunt"	43	43	Sat.

Result(CELL module) LED	Result(CELL module) Status	Acceptance Criteria	Judgment	Result(CELL module) "Amp/%/Cunt"	Result(CELL module) Status	Acceptance Criteria	Judgment
"BYP" (LPRM Bypass)	See above	See above	Sat.	"CELL Conunt"	41	41	Sat.

Result(CELL module) LED	Result(CELL module) Status	Acceptance Criteria	Judgment	Result(CELL module) "Amp/%/Cunt"	Result(CELL module) Status	Acceptance Criteria	Judgment
"BYP" (LPRM Bypass)	See above	See above	Sat.	"CELL Conunt"	5	5	Sat.
Result LED	**Result Status**	**Acceptance Criteria**	**Judgment**	**Result(CELL module) LED**	**Result(CELL module) Status**	**Acceptance Criteria**	**Judgment**
				"INOP"	☑Turn On ☐Turn Off	Turn On	Sat.

Result(CELL module) LED	Result(CELL module) Status	Acceptance Criteria	Judgment	Result(CELL module) "Amp/%/Cunt"	Result(CELL module) Status	Acceptance Criteria	Judgment
"BYP" (LPRM Bypass)	See above	See above	Sat.	"CELL Conunt"	0	0	Sat.
Result(DAT/ST module) LED	**Status**	**Acceptance Criteria**	**Judgment**	**Result(CELL module) LED**	**Result(CELL module) Status**	**Acceptance Criteria**	**Judgment**
"LPRM4" of "LINE STATUS"	☑Turn On ☐Turn Off	Turn On	Sat.	"INOP"	☑Turn On ☐Turn Off	Turn On	Sat.

8.3 OPRM Region Determination (OPRM Automatic Bypass)

(1) Explanation of Test Item

In this test, it was checked that the OPRM region determination was performed in the correct manner in accordance with APRM level and Core Flow level variations.

(2) Test Result

4.3.3.1 Step1 (APRM Level: 0.0%, Core Flow Level:50.0%)

☑1) Run the following test pattern files on the "OSTS".

☑APRM 1: AP_00.0_FL_50.0_R0_Aprm1.csv : 10 : 03 : 43

☑APRM 2: AP_00.0_FL_50.0_R0_Aprm2.csv : 10 : 03 : 58

☑2) Check that status of discrete outputs, module display and PC data output on OSRS is as acceptance criteria in the table below.

Step	Test Pattern (Optical Signal Transmit Simulator)				Acceptance Criteria (Expected Output) (Discrete Output)	Remarks
	APRM data 1		APRM data 2		OPRM Automatic Bypass	
	APRM Level	Core Flow Level	APRM Level	Core Flow Level		
1	0.0%	50.0%	0.0%	50.0%	☑ON	

Step	Test Pattern (Optical Signal Transmit Simulator)				Acceptance Criteria (Expected Output) (Displays on CELL module)				Remarks
	APRM data 1		APRM data 2		APRM Level (APRM)	Core Flow Level (FLOW)	OPRM Automatic Bypass (BYP)	OPRM Operation Region (OPRM REGION)	
	APRM Level	Core Flow Level	APRM Level	Core Flow Level					
1	0.0%	50.0%	0.0%	50.0%	☑0.0%	☑50.0%	☑ON	☑OFF	

Step	Test Pattern (Optical Signal Transmit Simulator)				Acceptance Criteria (Expected Output) (Optical Signal Receive Simulator (PC data))			Remarks
	APRM Unit data 1		APRM Unit data 2		APRM Level [%]	FLOW Level [%]	OPRM Automatic Bypass	
	APRM Level	Core Flow Level	APRM Level	Core Flow Level				
1	0.0%	50.0%	0.0%	50.0%	☑0.0	☑50.0	☑ON	

Result		Acceptance Criteria	Judgment
Item	Status		
Discrete Output	See above	See above	Sat.
Displays on CELL module	See above	See above	Sat.
OSRS(PC data)	See above	See above	Sat.

8.4 Trip Determination Functions

To verify the trip determination functions, it was checked that trip determination was performed in the correct manner for the Growth Rate-Based Trip (GRA Trip), the Amplitude-Based Maximum Trip (ABA Trip), and the Period-Based Trip (PBDA Trip) algorithms in accordance with input variations.

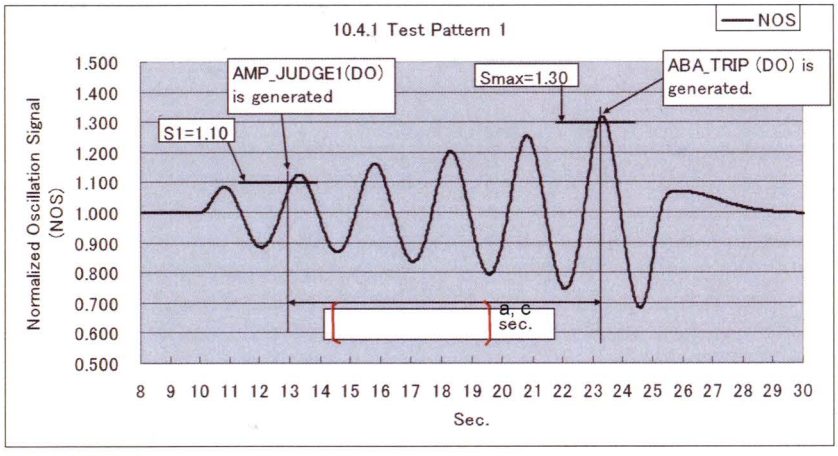
8.4.1 Amplitude-Based Maximum Trip (ABA Trip) Determination

The purpose of this test item is to check that trip determination is performed in the correct manner for the Amplitude-Based Maximum Trip (ABA Trip) determination.

1. Test Pattern 1

(1) Explanation of Test Item

This test pattern was used to check the ABA algorithm operation for 44 cells. LPRM Levels simulating a waveform that consisted of sine curve which amplitude value was amplified with time and a constant value were used as the test pattern. This test pattern simulates LPRM Levels for 52 channels so that the ABA trip occurs separately in CELL 1 though CELL 44. This test pattern also simulates LPRM Levels for 52 channels so that the AGA trip occurs simultaneously in CELL 1 through CELL 44 after the ABA trip occurs in 44 cells. This test pattern is set up not to make the GRA trip (Setpoint: DR = 1.3) occur. Using this test pattern, it was checked that an ABA trip occurred at each of 44 cells at the intervals of 5 seconds (i.e., 44 times in total), and then one ABA trip occurred at the end as an OR output of all of those 44 ABA trips. The following figure shows the wave form and expected output for this test pattern.



(2) Test Result

☑Check that status of discrete outputs is as acceptance criteria below.

Result(Scope Corder)		Acceptance Criteria	Judgment
Discrete Output	Status		
ABA_TRIP	45 (times)	45 times	Sat.
SCRAM (OPRM_TRIP)	45 (times)	45 times	Sat.
GRA_TRIP	☑Not occurred ☐Occurred	Not occurred	Sat.
PBDA_TRIP	☑Not occurred ☐Occurred	Not occurred	Sat.
Time difference between AMP_JUDGE1 and ABA_TRIP	[a, c]		Sat.

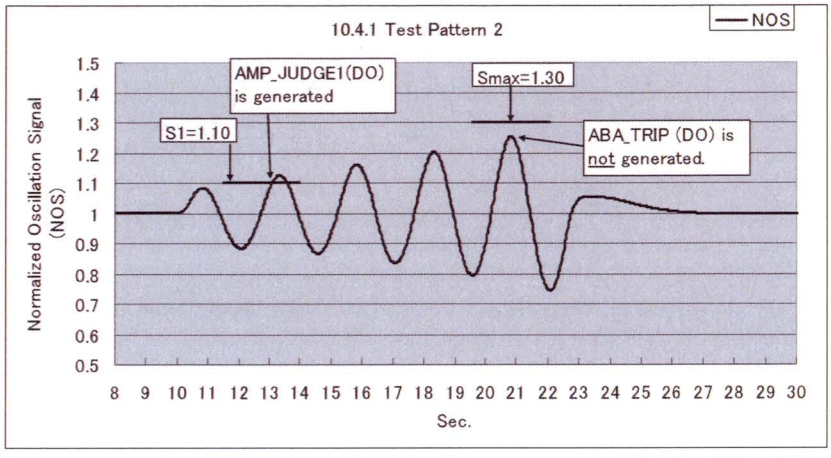
2. Test Pattern 2

(1) Explanation of Test Item

In this test pattern, CELL 2 was selected as a representative to check the detailed operation of the ABA algorithm.

This test pattern has following features:

A pattern that after the thresholds S1 and S2 are exceeded in the ABA algorithm, LPRM Levels with low amplitude peak simulating that Normalized Oscillation Signal (St) does not reach to Smax=1.3 on purpose. Using this pattern, it was checked that after the thresholds S1 and S2 were exceeded, the ABA trip did not occur in CELL 2. The following figure shows the wave form and expected output for this test pattern.



(2) Test Result

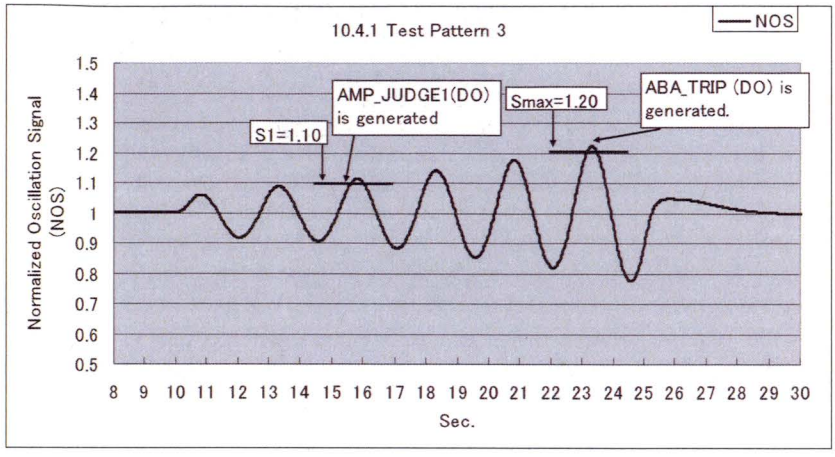
☑Check that the ABA trip does not occur in CELL 2.

Result		Acceptance Criteria	Judgment
ABA_Tirp	Status		
Discrete Outout	☑Not occurred ☐Occurred	Not occurred	Sat.
OSRS(ELCS/PICS data)	☑Not occurred ☐Occurred	Not occurred	Sat.

3. Test Pattern 3

(1) Explanation of Test Item

In this test pattern, CELL 3 was selected as a representative to check the detailed operation of the ABA algorithm when the Maximum Amplitude Trip Setpoint (Smax) was changed from 1.30 to 1.20. Using this test pattern, it was checked that the ABA trip occurred in CELL 3 as expected at setpoint of "Smax =1.20." The following figure shows the wave form and expected output for this test pattern.



(2) Test Result

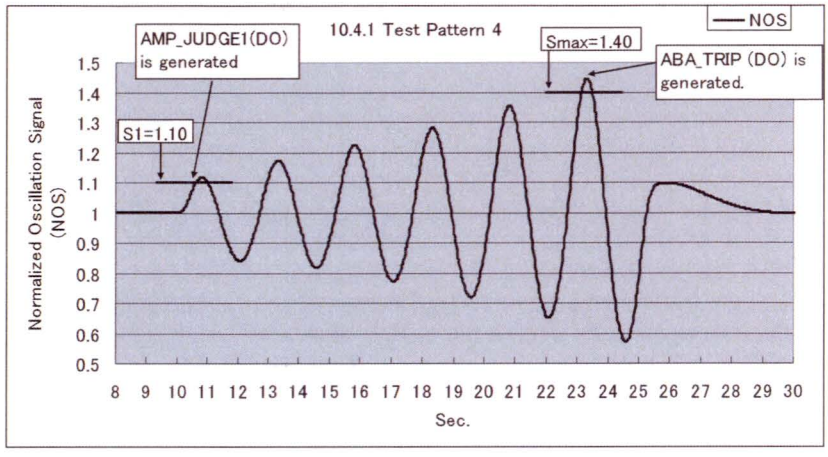
☑Check that the ABA trip occurs in CELL 3.

Result		Acceptance Criteria	Judgment
ABA_Tirp	Status		
Discrete Outout	☐Not occurred ☑Occurred	Occurred	Sat.
OSRS(ELCS/PICS data)	☐Not occurred ☑Occurred	Occurred	Sat.

4. Test Pattern 4

(1) Explanation of Test Item

In this test pattern, CELL 4 was selected as a representative to check the detailed operation of the ABA algorithm when the Maximum Amplitude Trip Setpoint (Smax) was changed to 1.40. Using this test pattern, it was checked that the ABA trip occurred in CELL 4 as expected at setpoint of "Smax =1.40." The following figure shows the wave form and expected output for this test pattern.



(2) Test Result

☑Check that the ABA trip occurs in CELL 4.

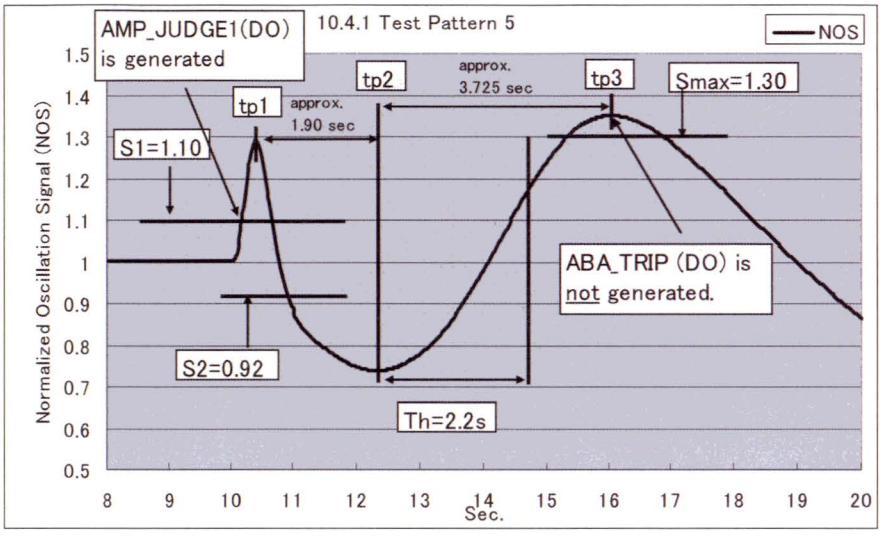
Result			Acceptance Criteria	Judgment
ABA_Tirp	Status			
Discrete Outout	☐Not occurred	☑Occurred	Occurred	Sat.
OSRS(ELCS/PICS data)	☐Not occurred	☑Occurred	Occurred	Sat.

5. Test Pattern 5

(1) Explanation of Test Item

In this test pattern, CELL 5 was selected as a representative to check the detailed operation of the ABA algorithm related to the setpoint of the Time Window for Trip Setpoint (Th = 2.20 s).

In this test, after the thresholds S1 and S2 were exceeded in the ABA algorithm, LPRM Levels with low frequency (equivalent to 0.2 Hz for the Normalized Oscillation Signal (St)) were input on purpose. Using this pattern, it was checked that after the thresholds S1 and S2 were exceeded, the ABA trip did not occur in CELL 5. The following figure shows the wave form and expected output for this test pattern.



(2) Test Result

☑Check that the ABA trip does not occur in CELL 5.

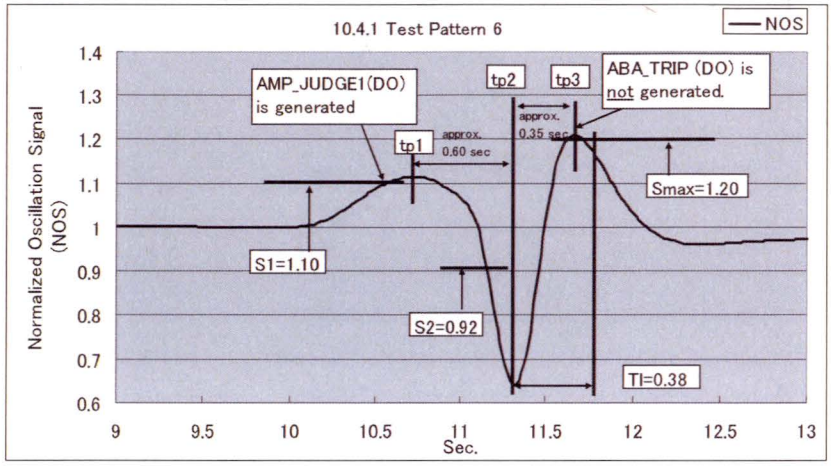
Result			Acceptance Criteria	Judgment
ABA_Tirp	Status			
Discrete Outout	☑Not occurred	☐Occurred	Not occurred	Sat.
OSRS(ELCS/PICS data)	☑Not occurred	☐Occurred	Not occurred	Sat.

6. Test Pattern 6

(1) Explanation of Test Item

In this test pattern, CELL 6 was selected as a representative to check the detailed operation of the ABA algorithm related to the setpoint of the Time Window for Minimum Threshold Setpoint (TI = 0.31 s).

In this test, after the thresholds S1 and S2 were exceeded in the ABA algorithm, LPRM Levels with high frequency (equivalent to 1.7 Hz for the Normalized Oscillation Signal (St)) were input on purpose. Using this pattern, it was checked that after the thresholds S1 and S2 were exceeded, the ABA trip did not occur in CELL 6. The following figure shows the wave form and expected output for this test pattern.



(2) Test Result

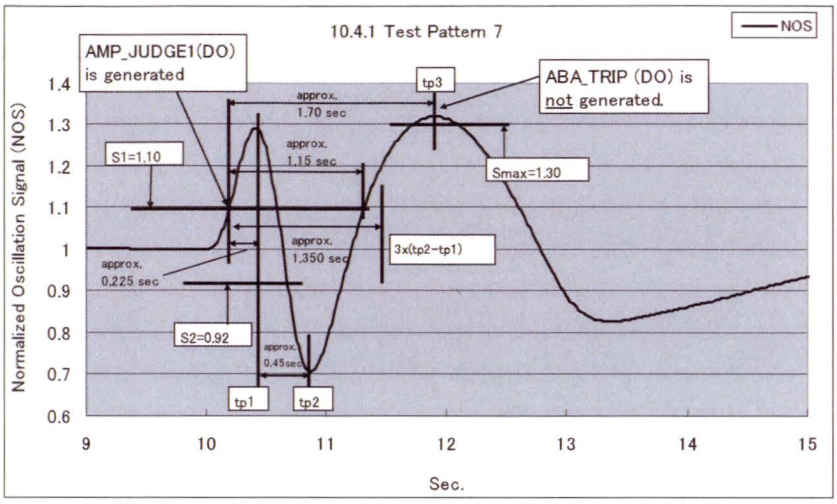
☑Check that the ABA trip does not occur in CELL 6.

Result		Acceptance Criteria	Judgment
ABA_Tirp	Status		
Discrete Outout	☑Not occurred ☐Occurred	Not occurred	Sat.
OSRS(ELCS/PICS data)	☑Not occurred ☐Occurred	Not occurred	Sat.

7. Test Pattern 7

(1) Explanation of Test Item

In this test pattern, CELL 7 was selected as a representative to check the detailed operation of the ABA algorithm. This test pattern simulates such LPRM Levels that after the thresholds S1 and S2 are exceeded in the ABA algorithm, LPRM Levels are slowly increased on purpose to exceed Smax after the elapse of the period of time 3×(tp2-tp1) following the fix of tp1 in the Normalized Oscillation Signal (St). Using this pattern, it was checked that after the thresholds S1 and S2 were exceeded, the ABA trip did not occur in CELL 7. The following figure shows the wave form and expected output for this test pattern.



(2) Test Result

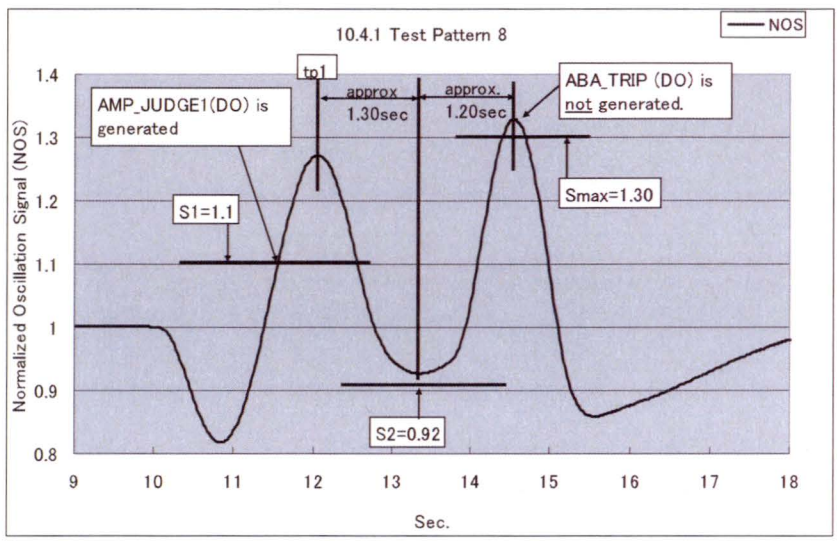
☑Check that the ABA trip does not occur in CELL 7.

Result			Acceptance Criteria	Judgment
ABA_Trip	Status			
Discrete Outout	☑Not occurred	☐Occurred	Not occurred	Sat.
OSRS(ELCS/PICS data)	☑Not occurred	☐Occurred	Not occurred	Sat.

8. Test Pattern 8

(1) Explanation of Test Item

In this test pattern, CELL 8 was selected as a representative to check the detailed operation of the ABA algorithm. This test pattern simulates such LPRM Levels that after the threshold S1 is exceeded in the ABA algorithm, LPRM Levels are slowly or swiftly decreased on purpose and then increased so that the threshold S2 is not exceeded. Using this pattern, it was checked that after the threshold S1 was exceeded, the threshold S2 was not exceeded and the ABA trip did not occur in CELL 8. The following figure shows the wave form and expected output for this test pattern.



(2) Test Result

☑Check that the ABA trip does not occur in CELL 8.

Result		Acceptance Criteria	Judgment
ABA_Tirp	Status		
Discrete Outout	☑Not occurred ☐Occurred	Not occurred	Sat.
OSRS(ELCS/PICS data)	☑Not occurred ☐Occurred	Not occurred	Sat.

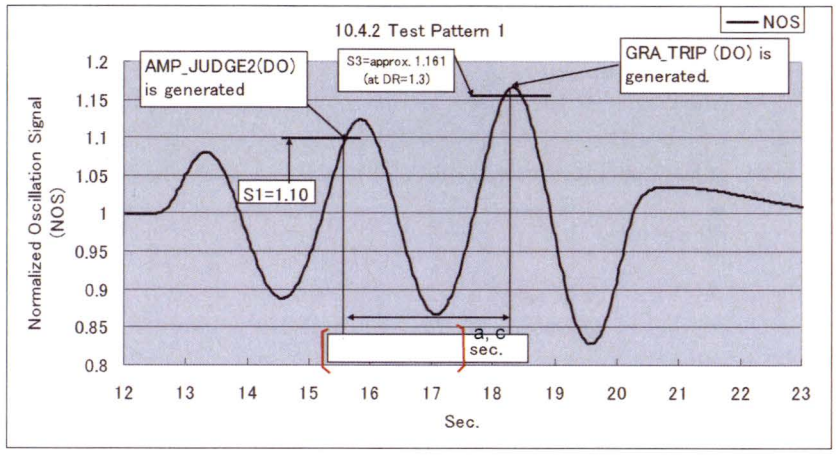
8.4.2 Growth Rate-Based Trip (GRA Trip) Determination

The purpose of this test item is to check that trip determination is performed in the correct manner for the Growth Rate-Based Trip (GRA Trip) determination.

1. Test Pattern 1

(1) Explanation of Test Item

This test pattern was used to check the GRA algorithm operation for 44 cells. LPRM Levels simulating a waveform that consisted of sine curve which amplitude value was amplified with time and a constant value were used as the test pattern. This test pattern simulates LPRM Levels for 52 channels so that the GRA trip occurs separately in CELL 1 though CELL 44. This test pattern also simulates LPRM Levels for 52 channels so that the AGA trip occurs simultaneously in CELL 1 through CELL 44 after the GRA trip occurs in 44 cells. Using this test pattern, it was checked that a GRA trip occurred at each of 44 cells at the intervals of 5 seconds (i.e., 44 times in total), and then one GRA trip occurred at the end as an OR output of all of those 44 GRA trips. The following figure shows the wave form and expected output for this test pattern.



(2) Test Result

☑Check that status of discrete outputs is as acceptance criteria below.

Result(Scope Corder)		Acceptance Criteria	Judgment
Discrete Output	Status		
GRA_TRIP	45 (times)	45 times	Sat.
SCRAM(OPRM_TRIP)	45 (times)	45 times	Sat.
ABA_TRIP	☑Not occurred ☐Occurred	Not occurred	Sat.
PBDA_TRIP	☑Not occurred ☐Occurred	Not occurred	Sat.
Time difference between AMP_JUDGE2 and GRA_TRIP	a, c		Sat.

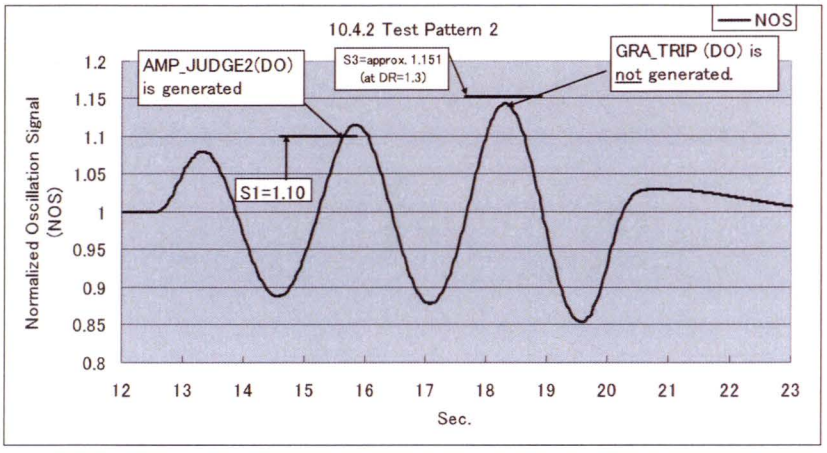
2. Test Pattern 2

(1) Explanation of Test Item

In this test pattern, CELL 12 was selected as a representative to check the detailed operation of the GRA algorithm.

This test pattern has following features:

A pattern that after the thresholds S1 and S2 are exceeded in the GRA algorithm, LPRM Levels with low amplitude peak simulating that Normalized Oscillation Signal (St) does not reach to S3 (Growth Rate Amplitude Setpoint (S3) = (P1-1.0) × DR3 + 1.0) on purpose. Using this pattern, it was checked that after the thresholds S1 and S2 were exceeded, the GRA trip did not occur in CELL 12. The following figure shows the wave form and expected output for this test pattern.



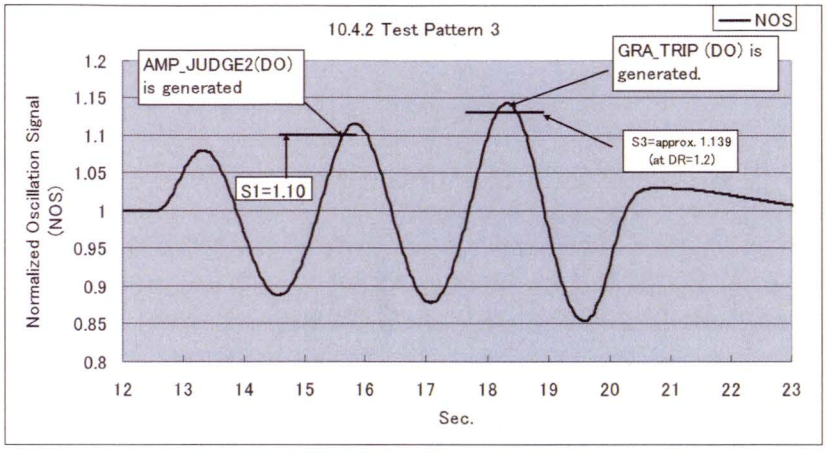
(2) Test Result

☑Check that the GRA trip does not occur in CELL 12.			
Result		**Acceptance Criteria**	**Judgment**
GRA_Tirp	**Status**		
Discrete Outout	☑Not occurred ☐Occurred	Not occurred	Sat.
OSRS(ELCS/PICS data)	☑Not occurred ☐Occurred	Not occurred	Sat.

3. Test Pattern 3

(1) Explanation of Test Item

In this test pattern, CELL 13 was selected as a representative to check the detailed operation of the GRA algorithm when the Growth Rate Factor (DR3) was changed from 1.3 to 1.2. Using this test pattern, it was checked that the GRA trip occurred in CELL 13 as expected at setpoint of "DR3 =1.2." The following figure shows the wave form and expected output for this test pattern.



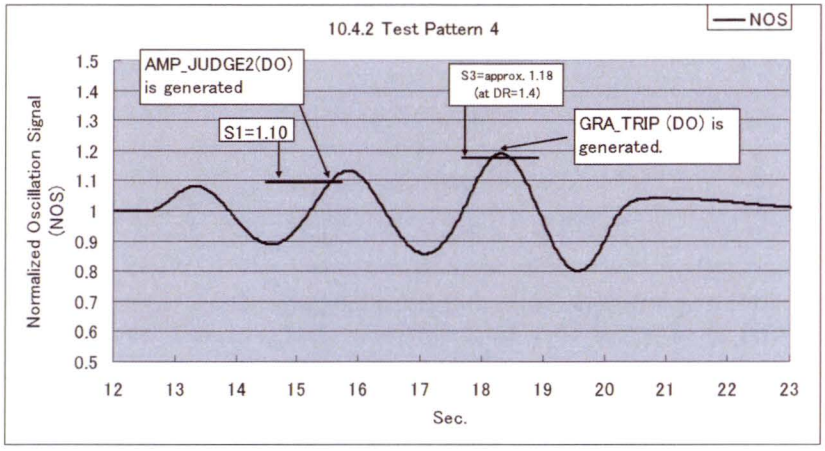
(2) Test Result

☑Check that the ABA trip occurs in CELL 13.				
Result			**Acceptance Criteria**	**Judgment**
GRA_Tirp	**Status**			
Discrete Outout	☐Not occurred	☑Occurred	Occurred	Sat.
OSRS(ELCS/PICS data)	☐Not occurred	☑Occurred	Occurred	Sat.

4. Test Pattern 4

(1) Explanation of Test Item

In this test pattern, CELL 14 is selected as a representative to check the detailed operation of the GRA algorithm when the Growth Rate Factor (DR3) was changed to 1.4. Using this test pattern, it was checked that the GRA trip occurred in CELL 14 as expected at setpoint of "DR3 =1.4." The following figure shows the wave form and expected output for this test pattern.



(2) Test Result

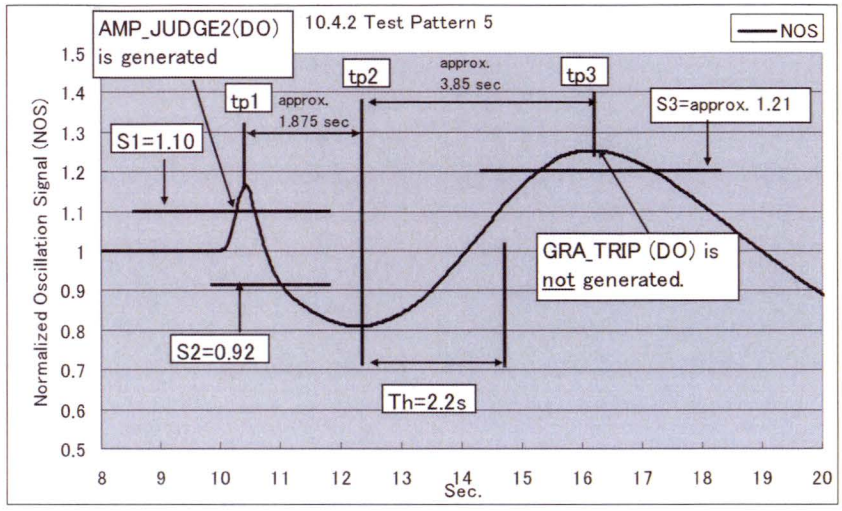
☑Check that the ABA trip occurs in CELL 14.			
Result		**Acceptance Criteria**	**Judgment**
GRA_Tirp	**Status**		
Discrete Outout	☐Not occurred ☑Occurred	Occurred	Sat.
OSRS(ELCS/PICS data)	☐Not occurred ☑Occurred	Occurred	Sat.

5. Test Pattern 5

(1) Explanation of Test Item

In this test pattern, CELL 15 was selected as a representative to check the detailed operation of the GRA algorithm related to the setpoint of the Time Window for Trip Setpoint (Th = 2.20 s).

In this test, after the thresholds S1 and S2 were exceeded in the GRA algorithm, LPRM Levels with low frequency (equivalent to 0.2 Hz for the Normalized Oscillation Signal (St)) were input on purpose. Using this pattern, it was checked that after the thresholds S1 and S2 were exceeded, the GRA trip did not occur in CELL 15. The following figure shows the wave form and expected output for this test pattern.



(2) Test Result

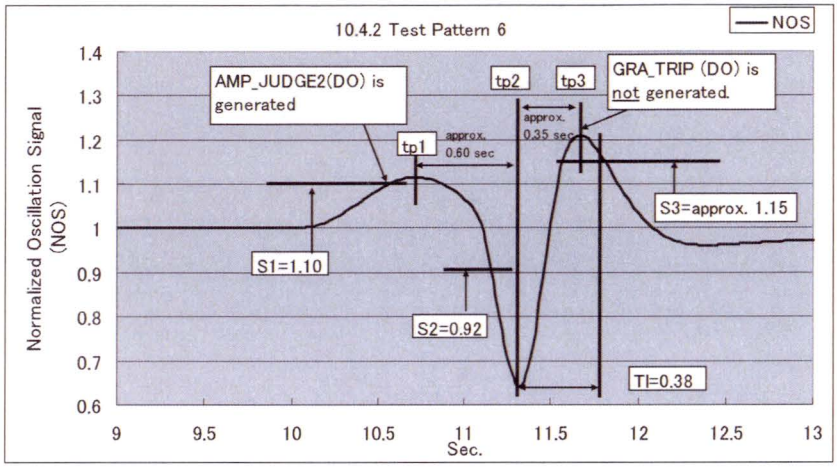
☑Check that the GRA trip does not occur in CELL 15.			
Result		**Acceptance Criteria**	**Judgment**
GRA_Tirp	**Status**		
Discrete Outout	☑Not occurred ☐Occurred	Not occurred	Sat.
OSRS(ELCS/PICS data)	☑Not occurred ☐Occurred	Not occurred	Sat.

6. Test Pattern 6

(1) Explanation of Test Item

In this test pattern, CELL 16 was selected as a representative to check the detailed operation of the GRA algorithm related to the setpoint of the Time Window for Minimum Threshold Setpoint (Tl = 0.31 s (in this test, the Tl was set to 0.38s.))

In this test, after the thresholds S1 and S2 were exceeded in the GRA algorithm, LPRM Levels with high frequency (equivalent to 1.7 Hz for the Normalized Oscillation Signal (St)) were input on purpose. Using this pattern, it was checked that after the thresholds S1 and S2 were exceeded, the GRA trip did not occur in CELL 16. The following figure shows the wave form and expected output for this test pattern.



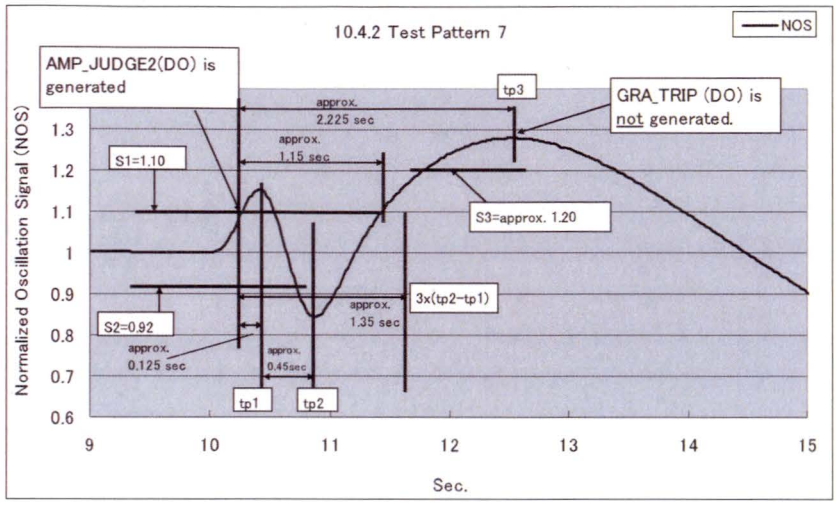
(2) Test Result

☑Check that the GRA trip does not occur in CELL 16.			
Result		**Acceptance Criteria**	**Judgment**
GRA_Tirp	**Status**		
Discrete Outout	☑Not occurred ☐Occurred	Not occurred	Sat.
OSRS(ELCS/PICS data)	☑Not occurred ☐Occurred	Not occurred	Sat.

7. Test Pattern 7

(1) Explanation of Test Item

In this test pattern, CELL 17 was selected as a representative to check the detailed operation of the GRA algorithm. This test pattern simulates such LPRM Levels that after the thresholds S1 and S2 are exceeded in the GRA algorithm, LPRM Levels are slowly increased on purpose to exceed S3 after the elapse of the period of time 3×(tp2-tp1) following the fix of tp1 in the Normalized Oscillation Signal (St). Using this pattern, it was checked that after the thresholds S1 and S2 were exceeded, the GRA trip did not occur in CELL 17. The following figure shows the wave form and expected output for this test pattern.



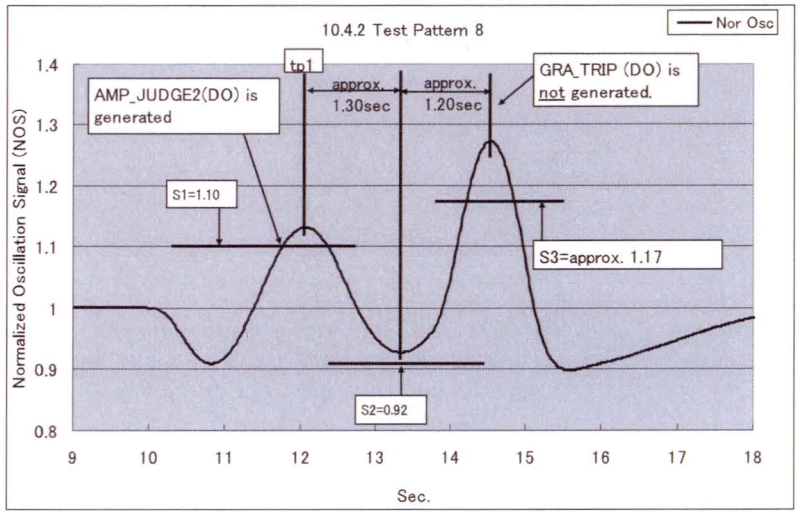
(2) Test Result

☑Check that the GRA trip does not occur in CELL 17.				
Result			**Acceptance Criteria**	**Judgment**
GRA_Tirp	**Status**			
Discrete Outout	☑Not occurred	☐Occurred	Not occurred	Sat.
OSRS(ELCS/PICS data)	☑Not occurred	☐Occurred	Not occurred	Sat.

8. Test Pattern 8

(1) Explanation of Test Item

In this test pattern, CELL 18 was selected as a representative to check the detailed operation of the GRA algorithm. This test pattern simulates such LPRM Levels that after the threshold S1 is exceeded in the GRA algorithm, LPRM Levels are slowly or swiftly decreased on purpose and then increased so that the threshold S2 is not exceeded. Using this pattern, it was checked that after the threshold S1 was exceeded, the threshold S2 was not exceeded and the GRA trip did not occur in CELL 18. The following figure shows the wave form and expected output for this test pattern.



(2) Test Result

☑Check that the GRA trip does not occur in CELL 18.			
Result		**Acceptance Criteria**	**Judgment**
GRA_Tirp	**Status**		
Discrete Outout	☑Not occurred ☐Occurred	Not occurred	Sat.
OSRS(ELCS/PICS data)	☑Not occurred ☐Occurred	Not occurred	Sat.

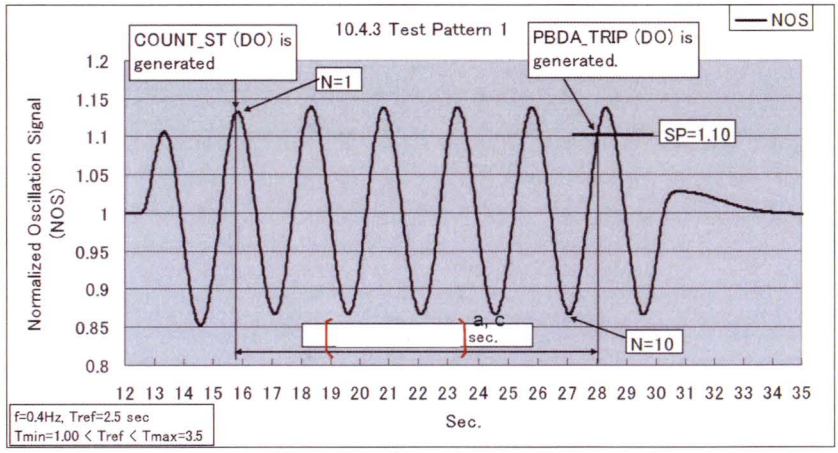
8.4.3 Period-Based Trip (PBDA Trip) Determination

The purpose of this test item is to check that trip determination is performed in the correct manner for the Period-Based Trip (PBDA Trip) determination.

1. Test Pattern 1

(1) Explanation of Test Item

This test pattern was used to check the PBDA algorithm operation for 44 cells. LPRM Levels simulating a waveform that consisted of sine curve and a constant value were used as the test pattern. This test pattern simulates LPRM Levels for 52 channels so that the PBDA trip occurs separately in CELL 1 though CELL 44. This test pattern also simulates LPRM Levels for 52 channels so that the PBDA trip occurs simultaneously in CELL 1 through CELL 44 after the GRA trip occurs in 44 cells. Using this test pattern, it was checked that an PBDA trip occurred at each of 44 cells at the intervals of 5 seconds (i.e., 44 times in total), and then one PBDA trip occurred at the end as an OR output of all of those 44 PBDA trips at the initial setpoints of "Np = 10" and "Sp = 1.1." The following figure shows the wave form and expected output for this test pattern.



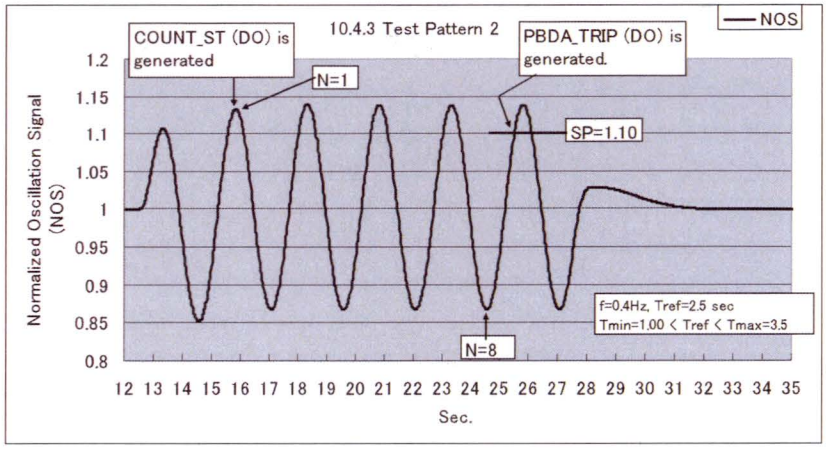
(2) Test Result

☑Check that status of discrete outputs is as acceptance criteria below.			
Result(Scope Corder)		**Acceptance Criteria**	**Judgment**
Discrete Output	**Status**		
PBDA_TRIP	45 (times)	45 times	Sat.
SCRAM(OPRM_TRIP)	45 (times)	45 times	Sat.
ABA_TRIP	☑Not occurred ☐Occurred	Not occurred	Sat.
GRA_TRIP	☑Not occurred ☐Occurred	Not occurred	Sat.
Time difference between COUNT_ST and PBDA_TRIP	[ ] a, c		Sat.

2. Test Pattern 2

(1) Explanation of Test Item

In this test pattern, CELL 22 was selected as a representative to check the detailed operation of the PBDA algorithm when the setpoint of the Confirmation Count Trip Setpoint (Np) was changed from 10 to 8. Using this test pattern, it was checked that the PBDA trip occurred in CELL 22 as expected at setpoint of "Np = 8." The following figure shows the wave form and expected output for this test pattern.



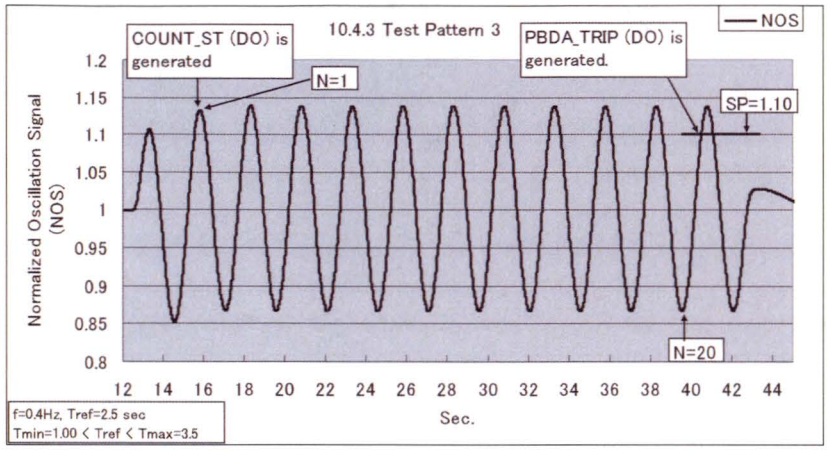
(2) Test Result

☑Check that the PBDA trip occurs in CELL 22.				
Result			**Acceptance Criteria**	**Judgment**
PBDA_Tirp	**Status**			
Discrete Outout	☐Not occurred	☑Occurred	Occurred	Sat.
OSRS(ELCS/PICS data)	☐Not occurred	☑Occurred	Occurred	Sat.

3. Test Pattern 3

(1) Explanation of Test Item

In this test pattern, CELL 23 was selected as a representative to check the detailed operation of the PBDA algorithm when the setpoint of the Confirmation Count Trip Setpoint (Np) was changed to 20. Using this test pattern, it was checked that the PBDA trip occurred in CELL 23 as expected at setpoint of "Np = 20." The following figure shows the wave form and expected output for this test pattern.



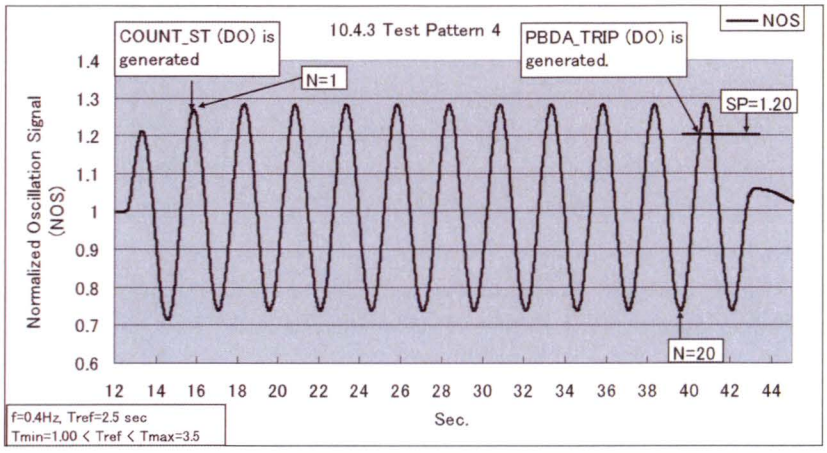
(2) Test Result

☑Check that the PBDA trip occurs in CELL 23.				
Result			**Acceptance Criteria**	**Judgment**
PBDA_Tirp	**Status**			
Discrete Outout	☐Not occurred	☑Occurred	Occurred	Sat.
OSRS(ELCS/PICS data)	☐Not occurred	☑Occurred	Occurred	Sat.

4. Test Pattern 4

(1) Explanation of Test Item

In this test pattern, CELL 24 was selected as a representative to check the detailed operation of the PBDA algorithm when the setpoint of the PBDA Amplitude Setpoint (Sp) was changed from 1.1 to 1.2 at the setpoint of the Confirmation Count Trip Setpoint (Np =20). Using this test pattern, it was checked that the PBDA trip occurred in CELL 24 as expected at setpoints of "Np = 20" and "Sp = 1.2." The following figure shows the wave form and expected output for this test pattern.



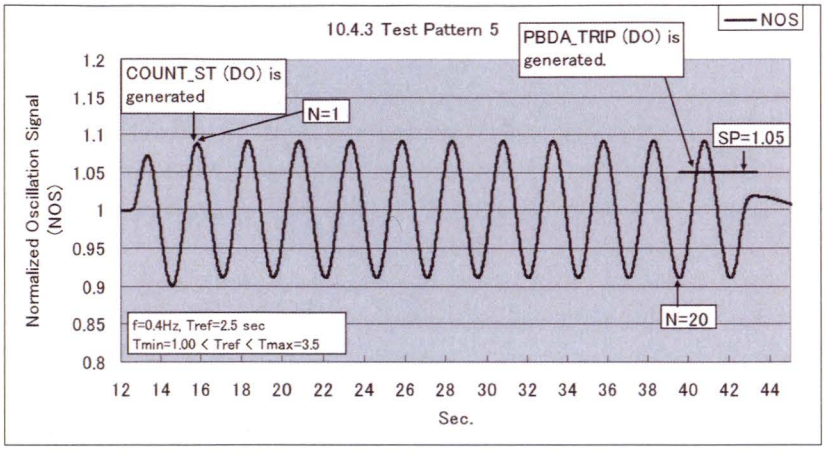
(2) Test Result

☑Check that the PBDA trip occurs in CELL 24.				
Result			**Acceptance Criteria**	**Judgment**
PBDA_Tirp	**Status**			
Discrete Outout	☐Not occurred	☑Occurred	Occurred	Sat.
OSRS(ELCS/PICS data)	☐Not occurred	☑Occurred	Occurred	Sat.

5. Test Pattern 5

(1) Explanation of Test Item

In this test pattern, CELL 25 was selected as a representative to check the detailed operation of the PBDA algorithm when the setpoint of the PBDA Amplitude Setpoint (Sp) was changed to 1.05 at the setpoint of the Confirmation Count Trip Setpoint (Np =20). Using this test pattern, it was checked that the PBDA trip occurred in CELL 25 as expected at setpoints of "Np = 20" and "Sp = 1.05." The following figure shows the wave form and expected output for this test pattern.



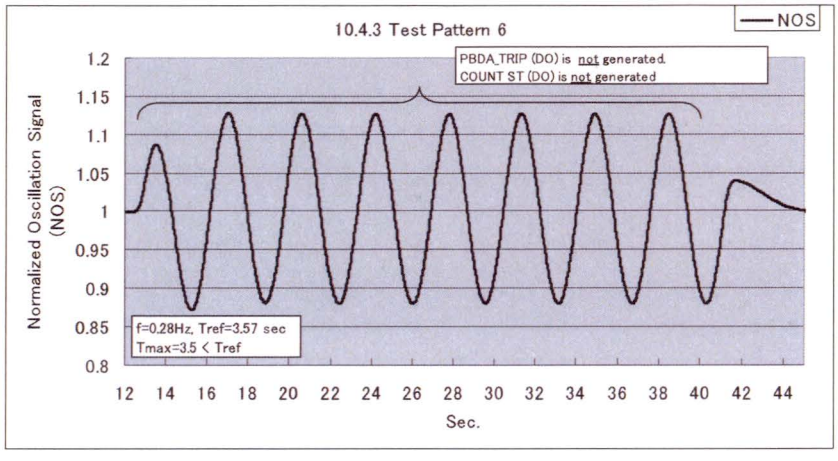
(2) Test Result

☑Check that the PBDA trip occurs in CELL 25.				
Result			**Acceptance Criteria**	**Judgment**
PBDA_Tirp	**Status**			
Discrete Outout	☐Not occurred	☑Occurred	Occurred	Sat.
OSRS(ELCS/PICS data)	☐Not occurred	☑Occurred	Occurred	Sat.

6. Test Pattern 6

(1) Explanation of Test Item

In this test pattern, CELL 26 was selected as a representative to check the detailed operation of the PBDA algorithm related to the setpoint of the Period Maximum Setpoint (Tmax = 3.50s). In this test, the LPRM Levels with low frequency (equivalent to 0.28 Hz (Tref=3.57s) for the Normalized Oscillation Signal (St)) were input on purpose. Using this pattern, it was checked that the PBDA trip did not occur in CELL 26 because the Tref was longer than Tmax, and the Confirmation Count did not count up. The following figure shows the wave form and expected output for this test pattern.



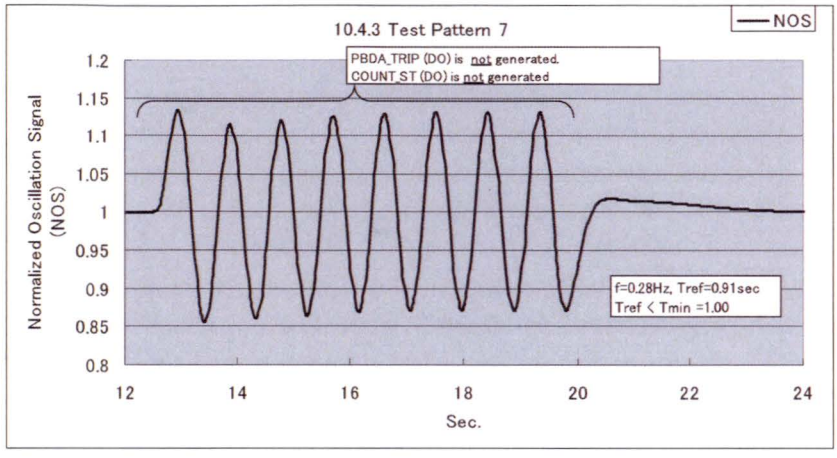
(2) Test Result

☑Check that the PBDA trip does not occur in CELL 26.				
Result			**Acceptance Criteria**	**Judgment**
PBDA_Tirp	**Status**			
Discrete Outout	☑Not occurred	☐Occurred	Not occurred	Sat.
OSRS(ELCS/PICS data)	☑Not occurred	☐Occurred	Not occurred	Sat.

7. Test Pattern 7

(1) Explanation of Test Item

In this test pattern, CELL 27 was selected as a representative to check the detailed operation of the PBDA algorithm related to the setpoint of the Period Minimum Setpoint (Tmin = 1.00s). In this test, the LPRM Levels with high frequency (equivalent to 1.7 Hz (Tref=0.91s) for the Normalized Oscillation Signal (St)) were input on purpose. Using this pattern, it was checked that the PBDA trip did not occur in CELL 27. The following figure shows the wave form and expected output for this test pattern.



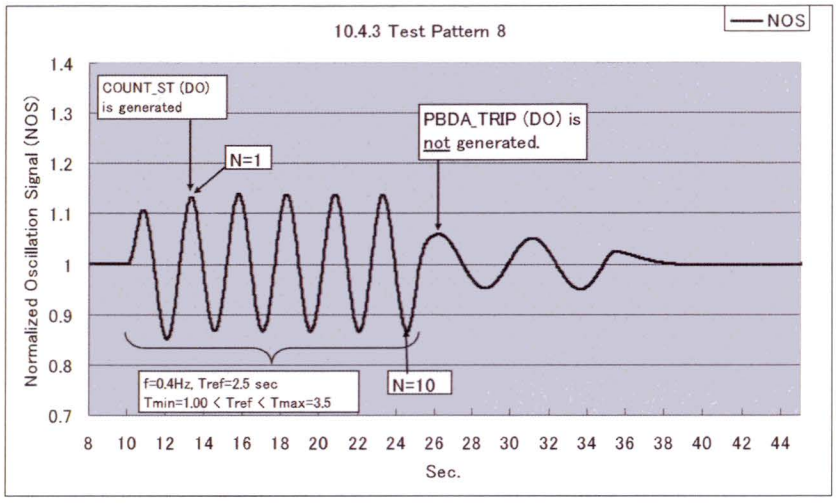
(2) Test Result

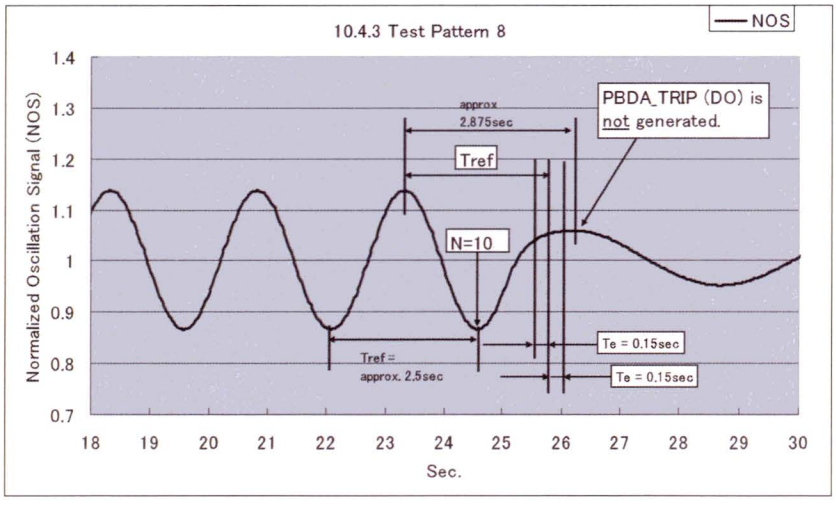
☑Check that the PBDA trip does not occur in CELL 27.				
Result			**Acceptance Criteria**	**Judgment**
PBDA_Tirp	**Status**			
Discrete Outout	☑Not occurred	☐Occurred	Not occurred	Sat.
OSRS(ELCS/PICS data)	☑Not occurred	☐Occurred	Not occurred	Sat.

8. Test Pattern 8

(1) Explanation of Test Item

In this test pattern, CELL 28 was selected as a representative to check the detailed operation of the PBDA algorithm related to the setpoint of the Period Tolerance Setpoint (Te = 0.15s). In this test, a pattern that after the Confirmation Count (N) counted up to 10 in the PBDA algorithm, LPRM Levels with low frequency were input on purpose. Using this pattern, it was checked that the PBDA trip did not occur in CELL 28 because the period between the subsequent peak and peak was larger than the period between the preceding valley and valley with a tolerance given by the Period Tolerance Setpoint, and the Confirmation Count was reset. The following figures show the wave form and expected output for this test pattern.





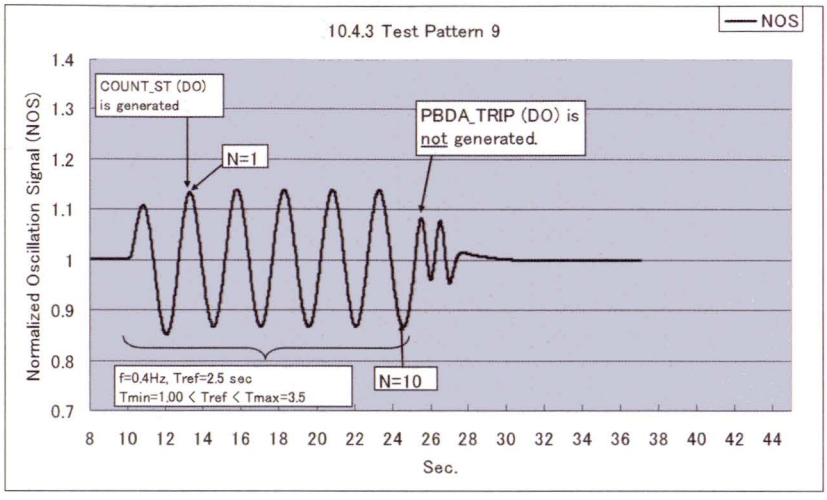
(2) Test Result

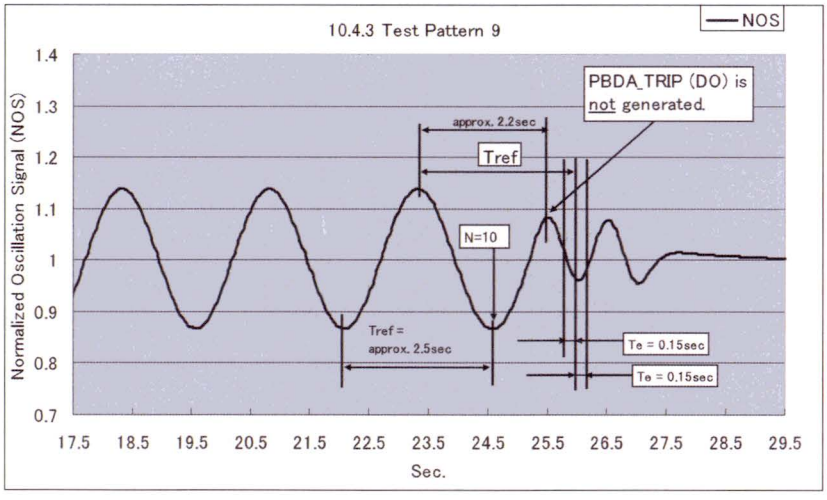
☑Check that the PBDA trip does not occur in CELL 28.				
Result			**Acceptance Criteria**	**Judgment**
PBDA_Tirp	**Status**			
Discrete Outout	☑Not occurred	☐Occurred	Not occurred	Sat.
OSRS(ELCS/PICS data)	☑Not occurred	☐Occurred	Not occurred	Sat.

9. Test Pattern 9

(1) Explanation of Test Item

In this test pattern, CELL 29 was selected as a representative to check the detailed operation of the PBDA algorithm related to the setpoint of the Period Tolerance Setpoint (Te = 0.15s). In this test, a pattern that after the Confirmation Count (N) counted up to 10 in the PBDA algorithm, LPRM Levels with high frequency were input on purpose. Using this pattern, it was checked that the PBDA trip did not occur in CELL 29 because the period between the subsequent peak and peak was smaller than the period between the preceding valley and valley with a tolerance given by the Period Tolerance Setpoint, and the Confirmation Count was reset. The following figures show the wave form and expected output for this test pattern.





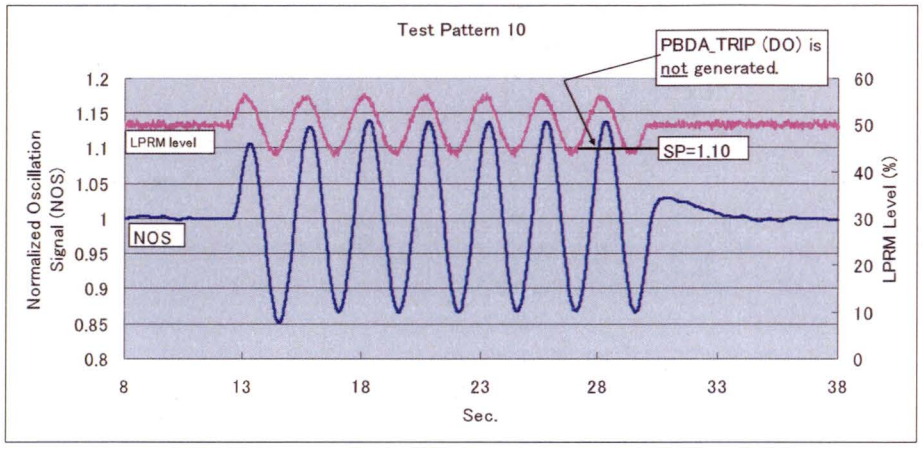
(2) Test Result

☑Check that the PBDA trip does not occur in CELL 29.				
Result			**Acceptance Criteria**	**Judgment**
PBDA_Tirp	**Status**			
Discrete Outout	☑Not occurred	☐Occurred	Not occurred	Sat.
OSRS(ELCS/PICS data)	☑Not occurred	☐Occurred	Not occurred	Sat.

10. Test Pattern 10

(1) Explanation of Test Item

In this test pattern, CELL 30 was selected as a representative to check the detailed operation of the PBDA algorithm related to the setpoint of the Peak and Valley Detection Width Setpoint (a). In this test, oscillating LPRM Levels with random noise were input on purpose. .Using this pattern, it was checked that Confirmation Count (N) counted up and reset to "0" at random in CELL 30, and a PBDA trip signal was not generated at the setpoint of "Peak and Valley Detection Width Setpoint (a) = 0.001" because the fluctuation in the Normalized Oscillation Signal due to the noise in the LPRM Levels reset the Confirmation Count at random with this setpoint value. The following figure shows the wave form and expected output for this test pattern.



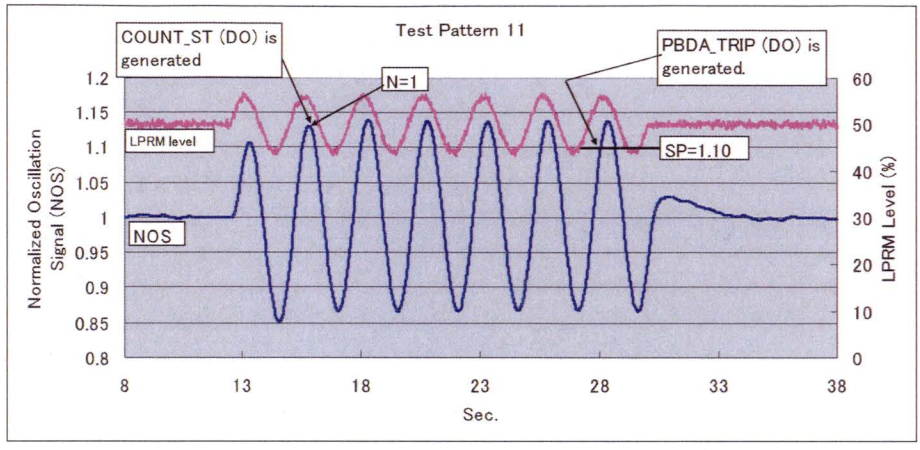
(2) Test Result

☑Check that the PBDA trip does not occur in CELL 30.				
Result			**Acceptance Criteria**	**Judgment**
PBDA_Tirp	**Status**			
Discrete Outout	☑Not occurred	☐Occurred	Not occurred	Sat.
OSRS(ELCS/PICS data)	☑Not occurred	☐Occurred	Not occurred	Sat.

11. Test Pattern 11

(1) Explanation of Test Item

The same pattern used for Test Pattern 10 was used for this test pattern. In this test pattern, CELL 30 was selected as a representative to check the detailed operation of the PBDA algorithm related to the setpoint of the Peak and Valley Detection Width Setpoint (a). In this test, oscillating LPRM Levels with random noise were input on purpose. .Using this pattern, it was checked that Confirmation Count (N) counted up to 10 in CELL 30, and a PBDA trip signal was generated at the setpoint of "Peak and Valley Detection Width Setpoint (a) = 0.003" because the fluctuation in the Normalized Oscillation Signal due to the noise in the LPRM Levels was neglected, and the Confirmation Count was not reset with this setpoint value.



(2) Test Result

☑Check that the PBDA trip occurs in CELL 30.				
Result			**Acceptance Criteria**	**Judgment**
PBDA_Tirp	**Status**			
Discrete Outout	☐Not occurred	☑Occurred	Occurred	Sat.
OSRS(ELCS/PICS data)	☐Not occurred	☑Occurred	Occurred	Sat.

8.4.4 Trip Algorithm Initialization

The purpose of this test item is to check that the trip algorithm initialization is performed in the correct manner in accordance with input conditions changes. LPRM Levels simulating a waveform that consists of sine curve and a constant value are used as the test pattern. This test pattern simulates LPRM Levels for CELL 9, CELL 12, and CELL 30 so that the ABA Trip occurs in CELL 9, the GRA Trip occurs in CELL 12, and the PBDA trip occurs in CELL 30 simultaneously for 4 cycles with time period of 30 seconds.

(1) Explanation of Test Item

1. Test Pattern 1 (Trip Algorithm Initialization by APRM Bypass Cancelation)

The purpose of this test pattern is to check that trip algorithms are initialized when the APRM Bypass signal input turns from ON to OFF state.

2. Test Pattern 2 (Trip Algorithm Initialization by OPRM Inoperative Cancelation (AGRD module is STANDBY mode))

The purpose of this test pattern is to check that trip algorithms are initialized when the OPRM Inoperative signal to CELL module turns from ON to OFF state. The OPRM Inoperative signal to CELL module is simulated by changing the operation mode of AGRD module.

3. Test Pattern 3 (Trip Algorithm Initialization by OPRM Inoperative Cancelation (PBD module is STANDBY mode))

The purpose of this test pattern is to check that trip algorithms are initialized when the OPRM Inoperative signal to CELL module turns from ON to OFF state. The OPRM Inoperative signal to CELL module is simulated by changing the operation mode of PBD module.

4. Test Pattern 4 (Trip Algorithm Initialization by OPRM Automatic Bypass)

The purpose of this test pattern is to check that trip algorithms are initialized when the CELL module generates the OPRM Automatic Bypass signal.

5. Test Pattern 5 (Trip Algorithm Initialization by Number of Active LPRMs change)

The purpose of this test pattern is to check that trip algorithms are initialized when the number of active LPRMs in each Cell changes.

6. Test Pattern 6 (Trip Algorithm Initialization by CELL Bypass)

The purpose of this test pattern is to check that trip algorithms are initialized when the CELL Bypass in each Cell occurs.

(2) Test Result

☑Check that the discrete outputs change as acceptance criteria below.

No.	Trip	Upper;Result (Scope Corder) Lower; Acceptance Criteria				Judgment	Remarks
		ABA_TRIP	GRA_TRIP	PBDA_TRIP	SCRAM		
1	1st	☑Occurred ☐Not occurred **Occurred**	☑Occurred ☐Not occurred **Occurred**	☑Occurred ☐Not occurred **Occurred**	☑Occurred ☐Not occurred **Occurred**	Sat.	
2	2nd	☑Occurred ☐Not occurred **Occurred**	☑Occurred ☐Not occurred **Occurred**	☑Occurred ☐Not occurred **Occurred**	☑Occurred ☐Not occurred **Occurred**	Sat.	
3	3rd	☐Occurred ☑Not occurred **Not occurred**	☐Occurred ☑Not occurred **Not occurred**	☐Occurred ☑Not occurred **Not occurred**	☐Occurred ☑Not occurred **Not occurred**	Sat.	Trip algorithm initialization
4	4th	☑Occurred ☐Not occurred **Occurred**	☑Occurred ☐Not occurred **Occurred**	☑Occurred ☐Not occurred **Occurred**	☑Occurred ☐Not occurred **Occurred**	Sat.	

☑Check that the ELCS/PICS data change as acceptance criteria below.

No.	Trip	Upper;Result (ELCS/PICS data) Lower; Acceptance Criteria				Judgment	Remarks
		ABA_Trip (CELL 9)	GRA_Trip (CELL 12)	PBDA_Trip (CELL 30)	OPRM_Trip		
1	1st	☑Occurred ☐Not occurred **Occurred**	☑Occurred ☐Not occurred **Occurred**	☑Occurred ☐Not occurred **Occurred**	☑Occurred ☐Not occurred **Occurred**	Sat.	
2	2nd	☑Occurred ☐Not occurred **Occurred**	☑Occurred ☐Not occurred **Occurred**	☑Occurred ☐Not occurred **Occurred**	☑Occurred ☐Not occurred **Occurred**	Sat.	
3	3rd	☐Occurred ☑Not occurred **Not occurred**	☐Occurred ☑Not occurred **Not occurred**	☐Occurred ☑Not occurred **Not occurred**	☐Occurred ☑Not occurred **Not occurred**	Sat.	Trip algorithm initialization
4	4th	☑Occurred ☐Not occurred **Occurred**	☑Occurred ☐Not occurred **Occurred**	☑Occurred ☐Not occurred **Occurred**	☑Occurred ☐Not occurred **Occurred**	Sat.	

8.5 Failure Detection and Self Diagnosis Functions

Failure detection and self diagnosis functions of the OPRM unit under abnormal conditions were tested by simulating postulated failures of external system and internal modules equipment.

8.5.1 OPRM Inoperative

(1) Explanation of Test Item

The purpose of this test item is to check that the OPRM unit generates an OPRM Inoperative signal under the following conditions.

- APRM Unit Data both system transmission error is detected
- APRM Inoperative occurs (CELL module)
- "STANDBY" (or "CAL") mode is selected on CELL module
- "STANDBY" (or "CAL") mode is selected on AGRD module
- "STANDBY" (or "CAL") mode is selected on PBD module
- Number of Active OPRM Cell is lower than the setpoint (CELL module)

(2) Test Result

4.3.5.1.1 Step1 (APRM Unit Data both system transmission error is detected)

☑1) Click "All Stop" for APRM 1 and APRM 2 data on the OSTS. : 20 : 29 : 00

☑2) Check that the discrete outputs and module display changes as acceptance criteria below.

Step	Test Pattern		Acceptance Criteria (Expected Output)				
			Displays on modules				Discrete Outputs and Optical Signal Receive Simulator Viewer (ELCS/PICS)
	Optical Signal Transmit Simulator	Module Operations	CELL module (INOP)	AGRD module (INOP)	PBD module (INOP)	Others	OPRM Inoperative Signal
1	"All Stop" for APRM1 and APRM2 data	N/A	☑ON	☑ OFF	☑OFF	DAT/ST module ☐ FAIL/APRM 1: ON ☑ FAIL/APRM 2: ON	☑ON ☑ON

☑3) Check recovery from abnormal condition by checking that the OPRM unit can be set to "Normal Status" using the Form Ns.

Result		Acceptance Criteria	Judgment
Item	Status		
Discrete Outputs	See above	See above	Sat.
Displays on modules	See above	See above	Sat.
OSRS(ELCS/PICS data)	See above	See above	Sat.

8.5.2 OPRM Minor failure

(1) Explanation of Test Item

The purpose of this test item is to check that the OPRM unit generates an OPRM Minor Failure signal under the following conditions.

- LPRM unit data input error occurs.
- APRM unit data input error occurs.
- LVPS module power supply failure occurs.

(2) Test Result

4.3.5.2.1 Step1 (LPRM Unit 1 Data transmission failure is detected)

☑1) Remove the optical cable to J61 (BSL5 RCV module IN1) (LPRM unit 1 data)
21 : 08 : 20

☑2) Check that the discrete outputs and module display changes as acceptance criteria below.

Step	Test Pattern		Acceptance Criteria (Expected Output)					
			Displays on modules				Discrete Outputs and Optical Signal Receive Simulator Viewer (ELCS/PICS)	
	Optical Signal Transmit Simulator	Module Operations	CELL module (FAIL)	DAT/ST module (FAIL)	DAT/ST module (LINE STATUS)	DAT/ST module (LVPS ALARM)	OPRM Minor Failure Signal	OPRM Inoperative ABA Trip GRA Trip PBDA Trip OPRM Trip
1	Remove the optical cable to J61 (BSL 5 RCV module IN1).	N/A	☑ON	☑ON	FAIL/APRM 1: ☑OFF FAIL/APRM 2: ☑OFF FAIL/LPRM 1: ☑ON FAIL/LPRM 2: ☑OFF FAIL/LPRM 3: ☑OFF FAIL/LPRM 4: ☑OFF	LVPS 1: ☑OFF LVPS 2: ☑OFF	☑ON	☑OFF ☑OFF ☑OFF ☑OFF ☑OFF
							☐ON	☑OFF ☑OFF ☑OFF ☑OFF ☑OFF

☑3) Check recovery from abnormal condition by checking that the OPRM unit can be set to "Normal Status" using the Form Ns.
Recovery Time : 21 : 09 : 23

Result		Acceptance Criteria	Judgment
Item	Status		
Discrete Outputs	See above	See above	Sat.
Displays on modules	See above	See above	Sat.
OSRS(ELCS/PICS data)	See above	See above	Sat.

8.6 Other Functions

8.6.1 Test Functions

(1) Explanation of Test Item

An internal test circuit of the OPRM unit allows checking the algorithm operation of LPRM Bypass, OPRM Cell Bypass, OPRM Automatic Bypass, and ABA, GRA, PBDA Trips at "CAL" mode of CELL module. These test functions are used by users of the OPRM unit for surveillance testing. The purpose of this test items is to check that the test functions operate as expected in accordance with the OPRM Unit User's Manual (Reference (7)).

(2) Test Result

4.3.6.1.1 Step1 (ABA Trip Test (Test number 1))
☑1) Before this test, the OPRM unit can be set to "Normal Status" using the Form Ns.
☑2) Turn the key switch of the CELL module to "CAL" positon.
☑3) Press the "SELECT3" button on the right side of the key switch to turn on the "TEST St" LED (yellow).
☑4) A test number is displayed in the numerical display of "fa/FLOW/St TEST No./CAL/PARAMETER2."
Press the "+" button to increment a test number. Press the "-" button to decrement the test number.
- Test number 1: Test data for ABA Trip/ AGRD module
☑5) Select the test number 1 and press the "SET" button of the CELL module.

Result		Acceptance Criteria	Judgment
Trip	**Status**		
Discrete Output ABA_TRIP	☐Not occurred ☑Occurred	Occurred	Sat.
Discrete Output SCRAM	☐Not occurred ☑occurred	Occurred	Sat.
LED on AGRD module TRIP	☑Turn On ☐Turn Off	Turn On	Sat.
LED on AGRD module ABA TRIP	☑Turn On ☐Turn Off	Turn On	Sat.
OSRS(ELCS/PICS data) ABA_Trip	☐Not occurred ☑Occurred	Occurred	Sat.
OSRS(ELCS/PICS data) OPRM_Trip	☐Not occurred ☑Occurred	Occurred	Sat.

8.6.2 Discrete Input Signal Toggling

(1) Explanation of Test Item

The purpose of this test item is to check the response of the OPRM unit when APRM Bypass signal toggling (ON/OFF Cycle: 1 second +/- 10% interval for 1 minute).

(2) Test Result

Result		Acceptance Criteria	Judgment
Item	**Status**		
LED of CELL module "BYP"	☑Turns On and Off cyclically ☐Other than above	Turns On and Off cyclically	Sat.
Discrete Output OPRM_INOP	☑Not occurred ☐Occurred	Not occurred	Sat.
Discrete Output SCRAM	☑Not occurred ☐Occurred	Not occurred	Sat.

8.6.3 Optical Transmission Integrity Test

The integrity of optical transmission signals under abnormal conditions postulated is evaluated in this test.

1. Test Pattern 1 :LPRM Level Toggling

(1) Explanation of Test Item

The purpose of this test pattern is to check response of the OPRM unit when the OPRM unit receives abnormal LPRM data that drives all the LPRM level inputs from 0 to 125% at 1 Hz interval for one minute simultaneously. The CELL module generates an OPRM Inoperative signal because number of active OPRM Cell changes due to changes of LPRM levels.

(2) Test Result

☑Check the status of OPRM unit.

Result		Acceptance Criteria	Judgment
Item	Status		
LED of CELL module "INOP"	☑Turns On cyclically ☐Other than above	Turns On cyclically	Sat.
Discrete Output OPRM_INOP	☑Occurred cyclically ☐Other than above	Occurred cyclically	Sat.
Discrete Output SCRAM	☑Not occurred ☐Occurred	Not occurred	Sat.
OSRS(PC data) LPRM Level	☑Change from 0 to 125% cyclically ☐Other than above	Change from 0 to 125% cyclically	Sat.

2. Test Pattern 2: APRM Level and Core Flow Level Toggling

(1) Explanation of Test Item

The purpose of this test pattern is to check response of the OPRM unit when the OPRM unit receives abnormal APRM data that drives all the APRM level and Core Flow level inputs from 0 to 125% at 1 Hz interval for one minute simultaneously.

(2) Test Result

Result		Acceptance Criteria	Judgment
Item	Status		
Discrete Output OPRM_INOP	☑Not occurred ☐Occurred	Not occurred	Sat.
Discrete Output SCRAM	☑Not occurred ☐Occurred	Not occurred	Sat.
OSRS(PC data) APRM Level	☑Change from 0 to 125% cyclically ☐Other than above	Change from 0 to 125% cyclically	Sat.
OSRS(PC data) Core Flow Level	☑Change from 0 to 125% cyclically ☐Other than above	Change from 0 to 125% cyclically	Sat.

3. Test Pattern 3 : Parity error simulation

(1) Explanation of Test Item

The purpose of this test pattern is to check response of the OPRM unit when the OPRM unit receives transmission data with parity error from the LPRM units and APRM unit.

(2) Test Result

Result		Acceptance Criteria	Judgment
Item	Status		
LED of CELL module "FAIL" LED	☑Turn On ☐Other than above	Turn On	Sat.
LED of DAT/ST module "FAIL" LED	☑Turn On ☐Other than above	Turn On	Sat.
LED of DAT/ST module "FAIL" LED of "LPRM1" in "LINE STATUS"	☑Turn On ☐Other than above	Turn On	Sat.
LED of DAT/ST module "FAIL" LED of "LPRM2" in "LINE STATUS"	☑Turn On ☐Other than above	Turn On	Sat.
LED of DAT/ST module "FAIL" LEDof "LPRM3" in "LINE STATUS"	☑Turn On ☐Other than above	Turn On	Sat.
LED of DAT/ST module "FAIL" LEDof "LPRM4" in "LINE STATUS"	☑Turn On ☐Other than above	Turn On	Sat.
LED of DAT/ST module "FAIL" LEDof "APRM1" in "LINE STATUS"	☑Turn On ☐Other than above	Turn On	Sat.
LED of DAT/ST module "FAIL" LEDof "APRM2" in "LINE STATUS"	☑Turn On ☐Other than above	Turn On	Sat.
Discrete Output OPRM_INOP	☐Not occurred ☑Occurred	Occurred	Sat.
Discrete Output OPRM_FAIL	☐Not occurred ☑Occurred	Occurred	Sat.
Discrete Output SCRAM	☑Not occurred ☐Occurred	Not occurred	Sat.

4. Test Pattern 4: Random Data Input Simulation

(1) Explanation of Test Item

The purpose of this test pattern is to check response of the OPRM unit when the OPRM unit receives random data from the LPRM units and APRM unit for one minute simultaneously.

(2) Test Result

4.3.6.3.4.2 Step2

☑1) Run the test pattern files on the "OSTS" for 1 minute or more.

☑Run the following test pattern files.

☑LPRM 1: RANDOM_R0_LPRM1.csv : 15 : 14 : 21

☑LPRM 2: RANDOM_R0_LPRM2.csv : 15 : 14 : 29

☑LPRM 3: RANDOM_R0_LPRM3.csv : 15 : 14 : 35

☑LPRM 4: RANDOM_R0_LPRM4.csv : 15 : 14 : 41

☑APRM 1: RANDOM_R0_Aprm1.csv : 15 : 14 : 49

☑APRM 2: RANDOM_R0_Aprm2.csv : 15 : 14 : 57

Result		Acceptance Criteria	Judgment
Item	Status		
Discrete Output OPRM_INOP	☐Not occurred ☑Occurred	Occurred	Sat.

5. Test Pattern 5: Response of the OPRM unit when optical signals are input into the output port of the TRN module

(1) Explanation of Test Item

The purpose of this test pattern is to check response of the OPRM unit when optical signals are input into the output port of the TRN module.

(2) Test Result

Result		Acceptance Criteria	Judgment
Item	Status		
LED of DAT/ST module "FAIL" LED	☐Turn Off ☑Turn On	Turn On	sat.
LED of DAT/ST module "FAIL" LED of "APRM2" in "LINE STATUS"	☐Turn Off ☑Turn On	Turn On	sat.
LED of CELL module "FAIL" LED	☐Turn Off ☑Turn On	Turn On	sat.
LED of CELL module "INOP" LED	☑Turn Off ☐Turn On	Turn Off	sat.
LED of AGRD module "FAIL" and "INOP" LED	☑Turn Off ☐Turn On	Turn Off	sat.
LED of PBD module "FAIL" and "INOP" LED	☑Turn Off ☐Turn On	Turn Off	sat.
Discrete Output OPRM_INOP	☑Not occurred ☐Occurred	Not occurred	sat.
Discrete Output OPRM_FAIL	☐Not occurred ☑Occurred	Occurred	sat.
Discrete Output SCRAM	☑Not occurred ☐Occurred	Not occurred	sat.

8.6.4 Random HMI Operation

(1) Explanation of Test Item

The purpose of this test item is to check response of the OPRM unit when user operates the HMI (buttons) on the modules unintentionally at Operation (OP) mode of the OPRM unit.

(2) Test Result

Result		Acceptance Criteria	Judgment
LEDs of PBD module	Status		
"FAIL" LED	☑Turn Off ☐Turn On	Turn Off	sat.
"INOP" LED	☑Turn Off ☐Turn On	Turn Off	sat.
"TRIP" LED	☑Turn Off ☐Turn On	Turn Off	sat.

8.6.5 Initialization

(1) Explanation of Test Item

The purpose of this test item is to check the initialization function of the OPRM unit. In this test, it was checked that the discrete outputs (SCRAM, ABA_TRIP, GRA_TRIP, PBDA_TRIP, OPRM_INOP and OPRM_FAIL) were generated during the OPRM unit initialization.

(2) Test Result

4.3.6.5.1 Step2

☑1) Shut off the both of the redundant AC power sources to the test specimens. : 17 : 06 : 41

☑2) Check that status of discrete outputs.

Result			Acceptance Criteria	Judgment
Discrete Output	Status			
SCRAM	☐Not occurred	☑Occurred	Occurred	Sat.
ABA_TRIP	☐Not occurred	☑Occurred	Occurred	Sat.
GRA_TRIP	☐Not occurred	☑Occurred	Occurred	Sat.
PBDA_TRIP	☐Not occurred	☑Occurred	Occurred	Sat.
OPRM_INOP	☐Not occurred	☑Occurred	Occurred	Sat.
OPRM_FAIL	☐Not occurred	☑Occurred	Occurred	Sat.

4.3.6.5.2 Step3

☑1) Reapply the both of the redundant power sources at the same time : 17 : 07 : 06

☑2) Check that generation of discrete outputs continues for more than 100ms after the 5VDC of the LVPS module (LVPS1) turns on.

Result			Acceptance Criteria	Judgment
Discrete Output	Status			
SCRAM	☐Not occurred	☑Occurred	Occurred (more than 100ms)	Sat.
ABA_TRIP	☐Not occurred	☑Occurred	Occurred (more than 100ms)	Sat.
GRA_TRIP	☐Not occurred	☑Occurred	Occurred (more than 100ms)	Sat.
PBDA_TRIP	☐Not occurred	☑Occurred	Occurred (more than 100ms)	Sat.
OPRM_INOP	☐Not occurred	☑Occurred	Occurred (more than 100ms)	Sat.
OPRM_FAIL	☐Not occurred	☑Occurred	Occurred (more than 100ms)	Sat.

9. Test Anomaly Reporting

The anomalies found in the system validation test were record in the test log of the System Validation Test Record (Reference (16)). The anomalies during the system validation testing were as follows.

9.1 Site Nonconformance Notice Reports (SNNRs)

Significant events such as equipment malfunctions or software errors that affected test execution were not observed. SNNR was not issued for the software validation test.

9.2 Document Change Request

(1) Document Change Request (MRK-01450)

Contents of Anomaly

In the Step 4 of 10.2.2 "Normalized Oscillation Signal Processing (with LPRM bypass)" of Revision 2 of SVTP (Reference (14)), Test Personnel observed the deviation that the OPRM unit did not operate as expected in the acceptance criterion described in Table 10.2.2.-2 "The indicator of the DAT/ST Module "LPRM3" of "LINE STATUS" is turn on."

Disposition

The NICSD IV&V Team confirmed that this anomaly was the problem of the description of the SVTP (mistake not to delete unnecessary criterion), the OPRM unit operated correctly, and the test result was correct. Test Personnel issued the Document Change Request (MRK-01450) in accordance with NQ-2024 "Procedure for Document Control" (Reference (9)). The NICSD IV&V Team deleted this acceptance criterion, and issued the Revision 3 of the SVTP.

(2) Document Change Request (MRK-01466)

Contents of Anomaly

In the Test Pattern 6 of Growth Rated-Based Trip (GRA Trip) Determination, Test Personnel observed the deviation that the OPRM unit did not operate as expected in the acceptance criterion "GRA_TRIP signal is not generated" described in Table 10.4.4 of Revision 2 of the SVTP.

Disposition

The NICSD IV&V Team confirmed that this anomaly was the problem of the description of the SVTP (loss of necessary procedural steps to change relevant setpoint). Test Personnel issued the Document Change Request (MRK-01466) in accordance with NQ-2024. The NICSD IV&V Team added the necessary procedural steps to change the relevant setpoint, and issued the Revision 3 of the SVTP. After the Revision 3 of the SVTP issued, Test Personnel retested this test pattern, and confirmed that the OPRM unit operated as expected.

10. Test Results for Additional Validation

The Test Personnel performed the software validation test conducted in the additional system validation testing. in February 2013 in accordance with the approved System Validation Test Procedure for Additional Validation (Reference (21)), and documented the test result in the System Validation Test Record for Additional Validation (Reference (22)). The System Validation Test Record for Additional Validation was approved by the manager of NICS-QC.

The following subsections described the test result for each test item. The test results referenced in the following subsections were excerpted from the System Validation Test Record for Additional Validation.

In the following subsections, the test result of each item was reported using the following paragraphs.

(1) Explanation of Test Item

This paragraph explained the overview of each test item. For detailed test steps and acceptance criteria, refer to the SVTP for Additional Validation (Reference (20)).

(2) Test Result

This paragraph shows the excerpted test result from the System Validation Test Record for Additional Validation. Although test results included the record for setting prior to each test item, or test record for recovery check after the each test item, the NICSD IV&V Team only excerpted the test result that showed the significant test result demonstrating the function of the OPRM unit tested. If the test item included multiple test steps following multiple test results, the NICSD IV&V Team selected a representative step to show the typical test result, as appropriate. For all the detailed test result, refer to the System Validation Test Record for Additional Validation (Reference (22)).

10.1 Standard Setting Check (Initial Setpoint)

(1) Explanation of Test Item

The same parameter setting and jumper pin setting as those specified in Section 6 of the System Test Specification for Additional Validation (Reference (19)) were used as "Standard Settings" for the software validation test. It was checked that the parameters displayed on the module front panel were consistent with the values specified in "Standard Settings."

(2) Test Result

Form NsA : Normal Status for Additonal Validation(Operation) (3 of 8) Step No. 3.2.1 12)

2. Confiramation of "Standard Setting" of OPRM unit Operation)

CELL Module Parameter		Result		Judgment
PARMETER 1	PARMETER 2			
1	Time Average Filter Cut-off Frequency Setpoint	☑	0.167	Sat.
2	LPRM Lower-limit Setpoint	☑	5.0	
3	Conditioning Filter Cut-off Frequency Setpoint	☑	1.000	
4	Minimum Number of Active OPRM Cell Setpoint	☑	32	
5	OPRM Region APRM Level Setpoint	☑	30.0	
6	OPRM Region Core Flow Level Setpoint	☑	60.0	
7	OPRM Region APRM Level Hysteresis Setpoint	☑	1	
8	OPRM Region Core Flow Level Hysteresis Setpoint	☑	1	
9	Minimum Number of Active LPRMs	☑	2	

AGRD Module Parameter		Result		Judgment
PARMETER 1	PARMETER 2			
1	Threshold Setpoint (S1)	☑	1.20	Sat.
2	Minimum Threshold Setpoint (S2)	☑	0.92	
3	Growth Rate Factor (DR3)	☑	1.04	
4	Maximum Amplitude Trip Setpoint (Smax)	☑	1.30	
5	Growth Amplitude Setpoint(S3)	N/A		
6	Time Window for Minimum Threshold Setpoint (TI)	☑	0.31	
7	Time Window for Trip Setpoint (Th)	☑	2.80 a, c	
8	ABA and GRA Trip Hold Time Setpoint (Ttph)	☑	[redacted]	
9	Peak and Valley Detection Width Setpoint (a) (Note 1)	☑	0.003	

Note 1: This parameter is shown as 1 to 10 on the numerical display of the AGRD module.

PBD Module Parameter		Result		Judgment
PARMETER 1	PARMETER 2			
1	Period Minimum Setpoint (Tmin)	☑	1.00	Sat.
2	Period Maximum Setpoint (Tmax)	☑	5.50	
3	Period Tolerance Setpoint (Te)	☑	0.400	
4	Confirmation Count Trip Setpoint (Np)	☑	10	
5	PBDA Amplitude Trip Setpoint (Sp)	☑	1.10 a, c	
6	PBDA Trip Hold Time Setpoint (Ttph)	☑	[redacted]	
7	Peak and Valley Detection Width Setpoint(a) (Note 2)	☑	0.003	

Note 2: This parameter is shown as 1 to 10 on the numerical display of the PBD module.

Result		Acceptance Criteria	Judgment
Item	Status		
"Standard Setting" of OPRM unit	See above	See above	Sat.

10.2 CRC Function

(1) Explanation of Test Item

The NICSD IV&V Team determined the detailed test cases for CRC function check in Section 10.2 based on the considerations described blow. The OPRM unit contains two RCV modules to receive optical transmission data from the LPRM unit and the APRM unit. The RCV module mounted on BSL5 is used for receiving optical transmission data from the four LPRM units. The RCV module mounted on BSL6 is used for receiving optical transmission data from the APRM unit. The purpose of this test item is to check the CRC function generating an OPRM Minor Failure signal as a combinational function by the modules in the OPRM unit when the OPRM unit detects unmatched CRC codes in received data. In this test, the following 12 test cases were checked by sending incorrect CRC code to the RCV modules by changing the setting of slide switches on the printed circuit boards of the [ ]a,c used for sending APRM unit data and LPRM unit data, respectively. .

Step 1: LPRM Unit 1 Data transmission failure is detected
Step 2: LPRM Unit 1 Data transmission failure is restored
Step 3: LPRM Unit 2 Data transmission failure is detected
Step 4: LPRM Unit 2 Data transmission failure is restored
Step 5: LPRM Unit 3 Data transmission failure is detected
Step 6: LPRM Unit 3 Data transmission failure is restored
Step 7: LPRM Unit 4 Data transmission failure is detected
Step 8: LPRM Unit 4 Data transmission failure is restored
Step 9: APRM Unit Data 1 transmission failure is detected
Step 10: APRM Unit Data 1 transmission failure is restored
Step 11: APRM Unit Data 2 transmission failure is detected
Step 12: APRM Unit Data 2 transmission failure is restored

(2) Test Result

3.2.2 CRC Functions **(1 of 13)**

Step	Contents	Initial of Test Personnel
3.2.2.1	☑1)Perform the Step1 using the record sheet 2 of 13.	T.A
3.2.2.2	☑1)Perform the Step2 using the record sheet 3 of 13.	T.A
3.2.2.3	☑1)Perform the Step3 using the record sheet 4 of 13.	T.A
3.2.2.4	☑1)Perform the Step4 using the record sheet 5 of 13.	T.A
3.2.2.5	☑1)Perform the Step5 using the record sheet 6 of 13.	T.A
3.2.2.6	☑1)Perform the Step6 using the record sheet 7 of 13.	T.A
3.2.2.7	☑1)Perform the Step7 using the record sheet 8 of 13.	T.A
3.2.2.8	☑1)Perform the Step8 using the record sheet 9 of 13.	T.A
3.2.2.9	☑1)Perform the Step9 using the record sheet 10 of 13.	T.A
3.2.2.10	☑1)Perform the Step10 using the record sheet 11 of 13.	T.A
3.2.2.11	☑1)Perform the Step11 using the record sheet 12 of 13.	T.A
3.2.2.12	☑1)Perform the Step12 using the record sheet 13 of 13.	T.A

10.3 Additional Validation of Trip Algorithms

The purpose of this test item is to demonstrate that the OPRM unit performs its safety functions under specific conditions specified by NED with additional performance requirements for the OPRM Trip response time of the OPRM unit.

In this test, the OPRM trip function based on the Period Based Detection Algorithm (PBDA), Amplitude Based Algorithm (ABA), and Growth Rate Algorithm (GRA) was tested changing the parameters of input signal with different phase lag between four LPRM Levels comprising an OPRM Cell, and the different frequency of oscillation. The NICSD IV&V Team determined the following 10 test patterns shown in Table 10-1 based on the conditions and parameters specified in Section 2.8 (3) of the procurement specification (Reference (23)).

Table 10-1 List of Test Patterns

Test Pattern No.	Input Signal Conditions				Other Conditions	Trip generation check or not generation check	Response time check
	Frequency	Phase Lag against LPRM A (Degree)					
		LPRM B	LPRM C	LPRM D	a, c		
Test Pattern 1					None	Generation check	Not Applicable
Test Pattern 2					None	Generation check	Applicable
Test Pattern 3					None	Generation check	Applicable
Test Pattern 4					None	Generation check	Applicable
Test Pattern 5					None	Generation check	Applicable
Test Pattern 6					Simulated random noise is given to LPRM Levels.	Generation check	Not Applicable
Test Pattern 7					LPRM A and LPRM B are bypassed.	Generation check	Not Applicable
Test Pattern 8					LPRM A and LPRM B are bypassed.	Generation check	Not Applicable
Test Pattern 9					LPRM A and LPRM B are bypassed.	Generation check	Not Applicable
Test Pattern 10					The following specific setpoints different from the "Standard Settings" are applied Time Window for Trip Setpoint (Th): 2.20 Period Maximum Setpoint (Tmax): 3.50	Not generation check	Not Applicable

The following acceptance criteria for each output shown in Table 10-2 to check the functionality of the trip algorithms were used. Graphic explanation on acceptance criterion for each trip algorithm showing timing when to generate a trip signal is shown in Figures 10-1 through 10-3.

Table 10-2 Acceptance Criteria and Expected Outputs

Test Pattern No.	Items to be checked		Acceptance Criteria
	Type of signal/display	Signal name/displayed item	
Test Pattern 1 through 9	Optical Signal Receive Simulator Viewer (ELCS/[ ]a, c data and PC data)	OPRM Trip	The "OPRM Trip" signal is generated.
		PBDA Trip	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.
		GRA Trip	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.
		ABA Trip	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.
	Discrete Outputs	SCRAM	First "SCRAM" signal (Discrete) is generated within +/- 2 s of "OPRM Trip" signal (ELCS/[ ]a, c data).
		PBDA_TRIP	First "PBDA_TRIP" signal (Discrete) is generated within +/- 2s of "PBDA Trip" signal (ELCS/[ ]a, c data).
		GRA_TRIP	First "GRA_TRIP" signal (Discrete) is generated within +/- 2s of "GRA Trip" signal (ELCS/[ ]a, c data).
		ABA_TRIP	First "ABA_TRIP" signal (Discrete) is generated within +/- 2s of "ABA Trip" signal (ELCS/[ ]a, c data).
Test Pattern 10	Optical Signal Receive Simulator Viewer (ELCS/[ ]a, c data and PC data)	OPRM Trip	"OPRM Trip" signal is not generated.
		PBDA Trip	"PBDA Trip" signal is not generated.
		ABA Trip	"ABA Trip" signal is not generated.
		GRA Trip	"GRA Trip" signal is not generated.
	Discrete Outputs	OPRM_TRIP	"OPRM_TRIP" signal is not generated.
		PBDA_TRIP	"PBDA_TRIP" signal is not generated.
		ABA_TRIP	"ABA_TRIP" signal is not generated.
		GRA_TRIP	"GRA_TRIP" signal is not generated.

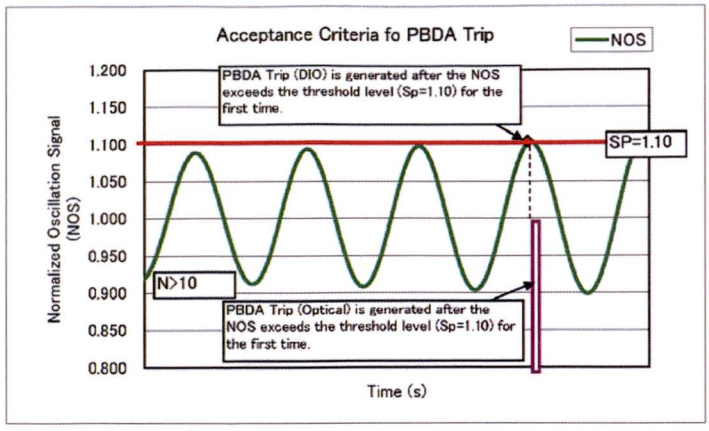


Figure 10-1 Acceptance Criteria of PBDA Trip

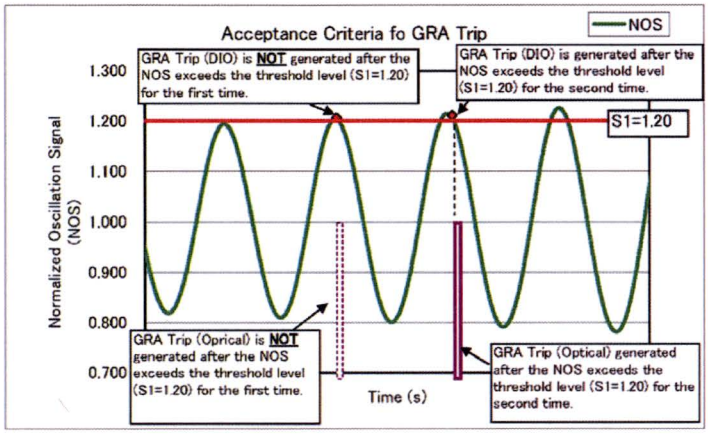


Figure 10-2 Acceptance Criteria of GRA Trip

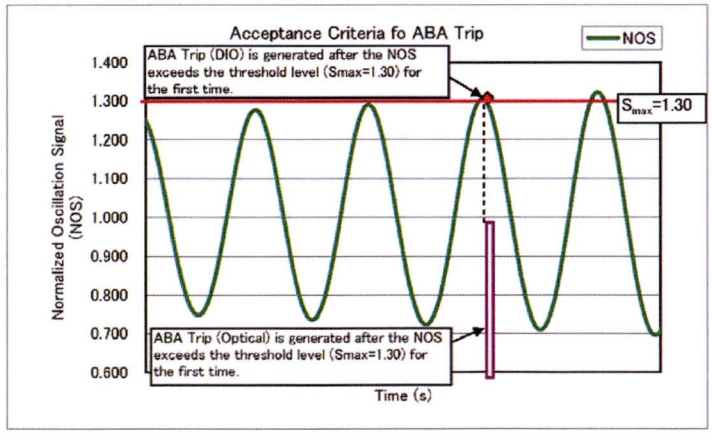


Figure 10-3 Acceptance Criteria of ABA Trip

The NCISD IV&V Team defined the acceptance criterion for the response time verification in the additional system validation testing as follows.

Response time (α) shall not exceed [ ]$^{a, c}$ ms, where

$$\alpha = X - \beta$$

β : Theoretically calculated time lag between the peak of ideal Normalized Oscillation Signal and the peak of LPRM A. LPRM A is an LPRM Level simulating input from the bottom LPRM detector, which has maximum amplitude of oscillation within the four LPRM Levels in an OPRM Cell that is dominant factor when calculating the Normalized Oscillation Signal.

X = A - B (s)

A: The time when the first PBDA Trip is generated observed in the optical signal output.

B: The time when the LPRM A reaches to peak position right before the first PBDA Trip observed in the optical signal output.

The detailed technical considerations which led to the above criterion were documented in Section 9 of the SVTP for Additional Validation (Reference (20)). Based on the above criterion, the following test acceptance criteria were determined as shown in Table 10-3. Graphic explanation on the acceptance criterion for each test pattern is shown in Figures 10-4 through 10-7.

Table 10-3 Acceptance Criteria of Response Time

Test Pattern No.	Items to be checked		Acceptance Criteria
	Type of signal/display	Response time(α)	
Test Pattern 2	Optical Signal Receive Simulator Viewer (PC data)	$\alpha = X - \beta$ β is [ ]$^{a, c}$ s (calculated value)	[ ]$^{a, c}$ s or less
Test Pattern 3	Optical Signal Receive Simulator Viewer (PC data)	$\alpha = X - \beta$ β is [ ]$^{a, c}$ s (calculated value)	[ ]$^{a, c}$ s or less
Test Pattern 4	Optical Signal Receive Simulator Viewer (PC data)	$\alpha = X - \beta$ β is [ ]$^{a, c}$ s (calculated value)	[ ]$^{a, c}$ s or less
Test Pattern 5	Optical Signal Receive Simulator Viewer (PC data)	$\alpha = X - \beta$ β is [ ]$^{a, c}$ s (calculated value)	[ ]$^{a, c}$ s or less

Note
X = A- B (s)
A: The duration when the first PBDA Trip is generated.
B: The duration when the LPRM A reaches to peak position right before the first PBDA Trip.

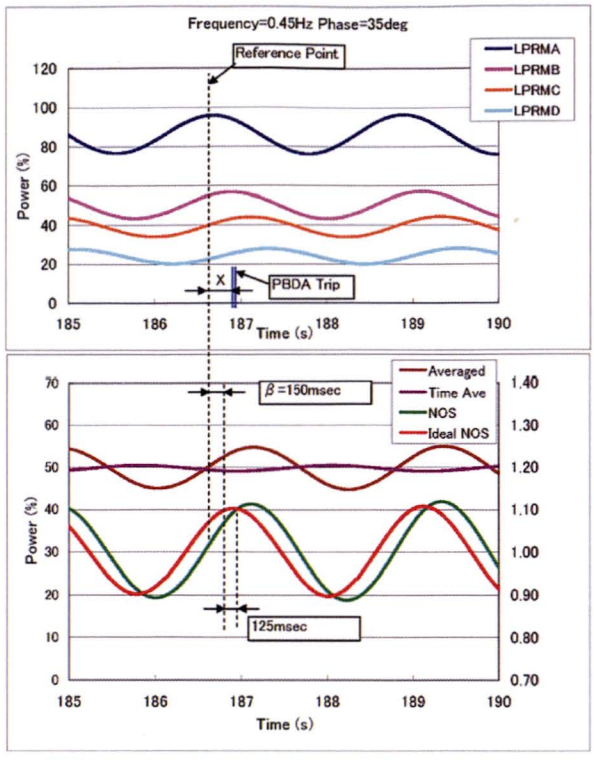


Figure 10-4 Wave Form and Expected Output for Test Pattern 2

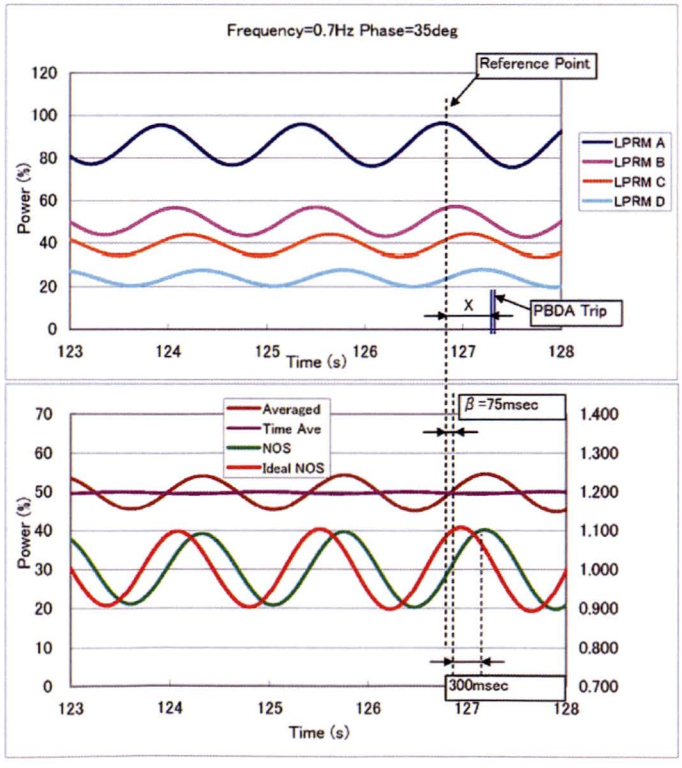


Figure 10-5 Wave Form and Expected Output for Test Pattern 3

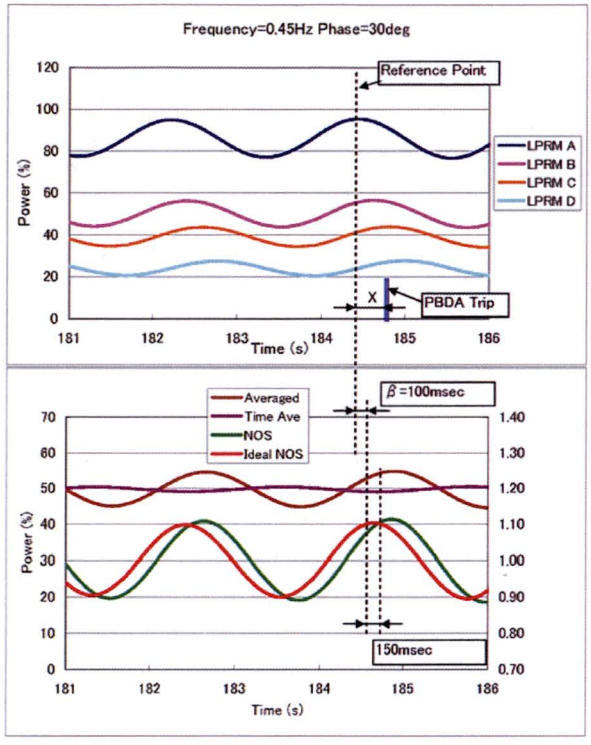


Figure 10-6 Wave Form and Expected Output for Test Pattern 4

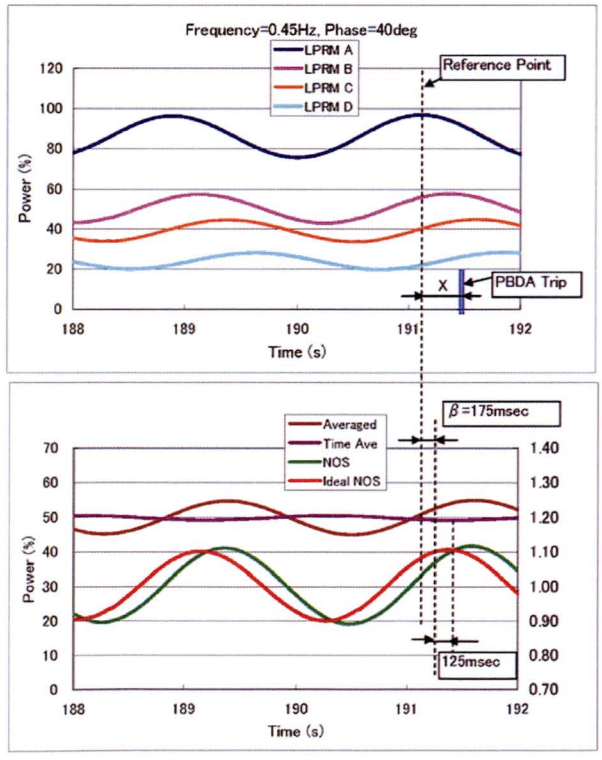


Figure 10-7 Wave Form and Expected Output for Test Pattern 5

1. Test Pattern 1

(1) Explanation of Test Item

Signals that oscillate at a frequency of [ ]a, c Hz are input as LPRM Levels (i.e., LPRM A through LPRM D) that make up Cell 2. Based on the LPRM A, the [ ]a, c -degree phase lag is set to LPRM B first, next the [ ]a, c -degree phase lag is set to LPRM C, and then finally the [ ]a, c -degree phase lag is set to LPRM D.

Acceptance criteria:

Status of discrete outputs, ELCS [ ]a, c data outputs and PC data outputs are as expected in Table 10-2.

(2) Test Result

3.2 Software Validation Test			(2 of 30)
3.2.3 Additional Validation of Trip Algorithms 3.2.3.1 Test Pattern 1 (Cell 2 Frequency 0.20Hz Phase Difference 35 Degrees)			
Result(Scope Corder) Result(ELCS/PICS data)		Acceptance Criteria	Judgment
Item	Time		
The time when the first SCRAM is generated (Discrete)	17 : 48 : 54	First "SCRAM" signal (Discrete) is generated within +/- 2s of "OPRM Trip" signal (ELCS/PICS data).	Sat.
The time when the first OPRMTrip is generated (Optical)	17 : 48 : 53		
The time when the first PBDA_TRIP is generated (Discrete)	17 : 48 : 54	The first "PBDA_TRIP" signal (Discrete) is generated within +/- 2s of "PBDA Trip" signal (ELCS/PICS data).	Sat.
The time when the first PBDA Trip is generated (Optical)	17 : 48 : 53	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Sat.
The time when the first GRA_TRIP is generated (Discrete)	17 : 50 : 05	The first "GRA_TRIP" signal (Discrete) is generated within +/- 2s of "GRA Trip" signal (ELCS/PICS data).	Sat.
The time when the first GRA Trip is generated (Optical)	17 : 50 : 05	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Sat.
The time when the first ABA_TRIP is generated (Discrete)	17 : 50 : 41	The first "ABA_TRIP" signal (Discrete) is generated within +/- 2s of "ABA Trip" signal (ELCS/PICS data).	Sat.
The time when the first ABA Trip is generated (Optical)	17 : 50 : 40	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.	Sat.

3.2 Software Validation Test			(3 of 30)
3.2.3 Additional Validation of Trip Algorithms 3.2.3.1 Test Pattern 1 (Cell 2 Frequency 0.20Hz Phase Difference 35 Degrees)			
Result(PC data)		Acceptance Criteria	Judgment
Item	Time		
The time when the first OPRMTrip is generated (Optical)	17: 48 : 53		
The time when the first PBDA Trip is generated (Optical)	17: 48 : 53	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Sat.
The time when the first GRA Trip is generated (Optical)	17 : 50 : 05	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Sat.
The time when the first ABA Trip is generated (Optical)	17 : 50 : 40	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.	Sat.

2. Test Pattern 2

(1) Explanation of Test Item

Signals that oscillate at a frequency of [ ]a, c Hz are input as LPRM Levels (i.e., LPRM A through D) that make up Cell 20. Based on the LPRM CH of LPRM A, the [ ]a, c -degree phase lag is set to LPRM B first, next the [ ]a, c -degree phase lag is set to LPRM C, and then finally the [ ]a, c -degree phase lag is set to LPRM D.

Acceptance criteria:

Status of discrete outputs, ELCS [ ]a, c data outputs and PC data outputs are as expected in Table 10-2.

Response time of the first PBDA Trip generation (PC data) is [ ]a, c s or less as described in Table 10-3.

(2) Test Result

3.2 Software Validation Test (5 of 30)			
3.2.3 Additional Validation of Trip Algorithms 3.2.3.2 Test Pattern 2 (Cell 20 Frequency 0.45Hz Phase Difference 35 Degrees)			
Result(Scope Corder) Result(ELCS/PICS data)		Acceptance Criteria	Judgment
Item	Time		
The time when the first SCRAM is generated (Discrete)	18 : 29 : 57	First "SCRAM" signal (Discrete) is generated within +/- 2s of "OPRM Trip" signal (ELCS/PICS data).	Sat.
The time when the first OPRMTrip is generated (Optical)	18 : 29 : 56		
The time when the first PBDA_TRIP is generated (Discrete)	18 : 29 : 57	The first "PBDA_TRIP" signal (Discrete) is generated within +/- 2s of "PBDA Trip" signal (ELCS/PICS data).	Sat.
The time when the first PBDA Trip is generated (Optical)	18 : 29 : 57	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Sat.
The time when the first GRA_TRIP is generated (Discrete)	18 : 30 : 31	The first "GRA_TRIP" signal (Discrete) is generated within +/- 2s of "GRA Trip" signal (ELCS/PICS data).	Sat.
The time when the first GRA Trip is generated (Optical)	18 : 30 : 31	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Sat.
The time when the first ABA_TRIP is generated (Discrete)	18 : 30 : 47	The first "ABA_TRIP" signal (Discrete) is generated within +/- 2s of "ABA Trip" signal (ELCS/PICS data).	Sat.
The time when the first ABA Trip is generated (Optical)	18 : 30 : 46	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.	Sat.

3.2 Software Validation Test (6 of 30)			
3.2.3 Additional Validation of Trip Algorithms 3.2.3.2 Test Pattern 2 (Cell 20 Frequency 0.45Hz Phase Difference 35 Degrees)			
Result(PC data)		Acceptance Criteria	Judgment
Item	Time		
The time when the first OPRMTrip is generated (Optical)	18 : 29 : 56		
The time when the first PBDA Trip is generated (Optical)	18 : 29 : 57	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Sat.
The time when the first GRA Trip is generated (Optical)	18 : 30 : 31	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Sat.
The time when the first ABA Trip is generated (Optical)	18 : 30 : 46	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.	Sat.
Response Time(PC data)		Acceptance Criteria	Judgment
Item	Duration		
(A) The duration when the first PBDA Trip is generated	[ ]a, c (s)		
(B) The duration when the LPRM A (LPRM CH 33) reaches to peak position right before the first PBDA Trip.	(s)		
X=(A)-(B)	(s)		
Response time(α)=X-β Note: β is 0.150s (calculated value)	(s)	0.325 s or less	Sat.

3. Test Pattern 3

(1) Explanation of Test Item

Signals that oscillate at a frequency of [ ]a, c Hz are input as LPRM Levels (i.e., LPRM A through D) that make up Cell 22. Based on the LPRM A, the [ ]a, c -degree phase lag is set to LPRM B first, next the [ ]a, c -degree phase lag is set to LPRM C, and then finally the [ ]a, c -degree phase lag is set to LPRM D.

Acceptance criteria:

Status of discrete outputs, ELCS [ ]a, c data outputs and PC data outputs are as expected in Table 10-2.

Response time of the first PBDA Trip generation (PC data) is [ ]a, c s or less as described in Table 10-3.

(2) Test Result

3.2 Software Validation Test (8 of 30)			
3.2.3 Additional Validation of Trip Algorithms **3.2.3.3 Test Pattern 3 (Cell 22 Frequency 0.70Hz Phase Difference 35 Degrees)**			
Result(Scope Corder) **Result(ELCS/PICS data)**		**Acceptance Criteria**	**Judgment**
Item	**Time**		
The time when the first SCRAM is generated (Discrete)	19 : 35 : 51	First "SCRAM" signal (Discrete) is generated within +/- 2s of "OPRM Trip" signal (ELCS/PICS data).	Sat.
The time when the first OPRMTrip is generated (Optical)	19 : 35 : 50		
The time when the first PBDA_TRIP is generated (Discrete)	19 : 35 : 51	The first "PBDA_TRIP" signal (Discrete) is generated within +/- 2s of "PBDA Trip" signal (ELCS/PICS data).	Sat.
The time when the first PBDA Trip is generated (Optical)	19 : 35 : 50	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Sat.
The time when the first GRA_TRIP is generated (Discrete)	19 : 36 : 13	The first "GRA_TRIP" signal (Discrete) is generated within +/- 2s of "GRA Trip" signal (ELCS/PICS data).	Sat.
The time when the first GRA Trip is generated (Optical)	19 : 36 : 12	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Sat.
The time when the first ABA_TRIP is generated (Discrete)	19 : 36 : 23	The first "ABA_TRIP" signal (Discrete) is generated within +/- 2s of "ABA Trip" signal (ELCS/PICS data).	Sat.
The time when the first ABA Trip is generated (Optical)	19 : 36 : 22	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.	Sat.

3.2 Software Validation Test (9 of 30)			
3.2.3 Additional Validation of Trip Algorithms **3.2.3.3 Test Pattern 3 (Cell 22 Frequency 0.70Hz Phase Difference 35 Degrees)**			
Result(PC data)		**Acceptance Criteria**	**Judgment**
Item	**Time**		
The time when the first OPRMTrip is generated (Optical)	19 : 35 : 50		
The time when the first PBDA Trip is generated (Optical)	19 : 35 : 50	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Sat.
The time when the first GRA Trip is generated (Optical)	19 : 36 : 12	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Sat.
The time when the first ABA Trip is generated (Optical)	19 : 36 : 22	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.	Sat.
Response Time(PC data)		**Acceptance Criteria**	**Judgment**
Item	**Status** a, c		
(A)The duration of the first PBDA Trip is occurred.	(s)		
(B) Peak duration of the LPRM A (LPRM CH 32) level before the first PBDA Trip.	(s)		
X=(A)-(B)	(s)		
Response time(α)=X-β Note: β is 0.075s (calculated value)	(s)	0.325 s or less	Sat.

4. Test Pattern 4

(1) Explanation of Test Item

Signals that oscillate at a frequency of [ ]a, c Hz are input as LPRM Levels (i.e., LPRM A through D) that make up Cell 24. Based on the LPRM A, the [ ]a, c degree phase lag is set to LPRM B first, next the [ ]a, c degree phase lag is set to LPRM C, and then finally the [ ]a, c degree phase lag is set to LPRM D.

Acceptance criteria:

Status of discrete outputs, ELCS [ ]a, c data outputs and PC data outputs are as expected in Table 10-2.

Response time of the first PBDA Trip generation (PC data) is [ ]a, c s or less as described in Table 10-3.

(2) Test Result

3.2 Software Validation Test (11 of 30)			
3.2.3 Additional Validation of Trip Algorithms 3.2.3.4 Test Pattern 4 (Cell 24 Frequency 0.45Hz Phase Difference 30 Degrees)			
Result(Scope Corder) Result(ELCS/PICS data)		Acceptance Criteria	Judgment
Item	Time		
The time when the first SCRAM is generated (Discrete)	19 : 57 : 52	First "SCRAM" signal (Discrete) is generated within +/- 2s of "OPRM Trip" signal (ELCS/PICS data).	Sat.
The time when the first OPRMTrip is generated (Optical)	19 : 57 : 51		
The time when the first PBDA_TRIP is generated (Discrete)	19 : 57 : 52	The first "PBDA_TRIP" signal (Discrete) is generated within +/- 2s of "PBDA Trip" signal (ELCS/PICS data).	Sat.
The time when the first PBDA Trip is generated (Optical)	19 : 57 : 51	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Sat.
The time when the first GRA_TRIP is generated (Discrete)	19 : 58 : 26	The first "GRA_TRIP" signal (Discrete) is generated within +/- 2s of "GRA Trip" signal (ELCS/PICS data).	Sat.
The time when the first GRA Trip is generated (Optical)	19 : 58 : 25	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Sat.
The time when the first ABA_TRIP is generated (Discrete)	19 : 58 : 41	The first "ABA_TRIP" signal (Discrete) is generated within +/- 2s of "ABA Trip" signal (ELCS/PICS data).	Sat.
The time when the first ABA Trip is generated (Optical)	19 : 58 : 41	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.	Sat.

3.2 Software Validation Test (12 of 30)			
3.2.3 Additional Validation of Trip Algorithms 3.2.3.4 Test Pattern 4 (Cell 24 Frequency 0.45Hz Phase Difference 30 Degrees)			
Result(PC data)		Acceptance Criteria	Judgment
Item	Time		
The time when the first OPRMTrip is generated (Optical)	19 : 57 : 51		
The time when the first PBDA Trip is generated (Optical)	19 : 57 : 51	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Sat.
The time when the first GRA Trip is generated (Optical)	19 : 58 : 25	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Sat.
The time when the first ABA Trip is generated (Optical)	19 : 58 : 41	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.	Sat.
Response Time(PC data)		Acceptance Criteria	Judgment
Item	Status a, c		
(A)The duration of the first PBDA Trip is occurred.	(s)		
(B) Peak duration of the LPRM A (LPRM CH 7) level before the first PBDA Trip.	(s)		
X=(A)-(B)	(s)		
Response time(α)=X- β Note: β is 0.100s (calculated value)	(s)	0.325 s or less	Sat.

5. Test Pattern 5

(1) Explanation of Test Item

Signals that oscillate at a frequency of [a, c] Hz are input as LPRM Levels (i.e., LPRM A through D) that make up Cell 35. Based on the LPRM A, the [a, c] degree phase lag is set to LPRM B first, next the [a, c] degree phase lag is set to LPRM C, and then finally the [a, c] degree phase lag is set to LPRM D.

Acceptance criteria:

Status of discrete outputs, ELCS [a, c] data outputs and PC data outputs are as expected in Table 10-2.

Response time of the first PBDA Trip generation (PC data) is [a, c] s or less as described in Table 10-3.

(2) Test Result

3.2 Software Validation Test (14 of 30)

3.2.3 Additional Validation of Trip Algorithms
3.2.3.5 Test Pattern 5 (Cell 35 Frequency 0.45Hz Phase Difference 40 Degrees)

Result(Scope Corder) / Result(ELCS/PICS data)		Acceptance Criteria	Judgment
Item	**Time**		
The time when the first SCRAM is generated (Discrete)	20 : 13 : 00	First "SCRAM" signal (Discrete) is generated within +/- 2s of "OPRM Trip" signal (ELCS/PICS data).	Sat.
The time when the first OPRMTrip is generated (Optical)	20 : 12 : 59		
The time when the first PBDA_TRIP is generated (Discrete)	20 : 13 : 00	The first "PBDA_TRIP" signal (Discrete) is generated within +/- 2s of "PBDA Trip" signal (ELCS/PICS data).	Sat.
The time when the first PBDA Trip is generated (Optical)	20 : 12 : 59	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Sat.
The time when the first GRA_TRIP is generated (Discrete)	20 : 13 : 34	The first "GRA_TRIP" signal (Discrete) is generated within +/- 2s of "GRA Trip" signal (ELCS/PICS data).	Sat.
The time when the first GRA Trip is generated (Optical)	20 : 13 : 33	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Sat.
The time when the first ABA_TRIP is generated (Discrete)	20 : 13 : 50	The first "ABA_TRIP" signal (Discrete) is generated within +/- 2s of "ABA Trip" signal (ELCS/PICS data).	Sat.
The time when the first ABA Trip is generated (Optical)	20 : 13 : 49	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.	Sat.

3.2 Software Validation Test (15 of 30)

3.2.3 Additional Validation of Trip Algorithms
3.2.3.5 Test Pattern 5 (Cell 35 Frequency 0.45Hz Phase Difference 40 Degrees)

Result(PC data)		Acceptance Criteria	Judgment
Item	**Time**		
The time when the first OPRMTrip is generated (Optical)	20 : 12 : 59		
The time when the first PBDA Trip is generated (Optical)	20 : 12 : 59	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Sat.
The time when the first GRA Trip is generated (Optical)	20 : 13 : 33	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Sat.
The time when the first ABA Trip is generated (Optical)	20 : 13 : 49	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.	Sat.

Response Time(PC data)			Acceptance Criteria	Judgment
Item	**Time**	[a, c]		
(A)The duration of the first PBDA Trip is occurred.		(s)		
(B) Peak duration of the LPRM A (LPRM CH 49) level before the first PBDA Trip.		(s)		
X=(A)-(B)		(s)		
Response time(α)=X- β Note: β is 0.175s (calculated value)		(s)	0.325 s or less	Sat.

6. Test Pattern 6

(1) Explanation of Test Item

Signals that oscillate at a frequency of [ ]a, c Hz are input as LPRM Levels (i.e., LPRM A through D) that make up Cell 38. Based on the LPRM A, the [ ]a, c -degree phase lag is set to LPRM B first, next the [ ]a, c -degree phase lag is set to LPRM C, and then finally the [ ]a, c -degree phase lag is set to LPRM D. It should be noted in this test pattern that simulated random noise is given to LPRM Levels at the frequency band from 3 to 33 Hz with maximum amplitude of 1.5 %.

Acceptance criteria:

Status of discrete outputs, ELCS [ ]a, c data outputs and PC data outputs are as expected in Table 10-2.

(2) Test Result

3.2 Software Validation Test (17 of 30)			
3.2.3 Additional Validation of Trip Algorithms **3.2.3.6 Test Pattern 6 (Cell 38 Frequency 0.45Hz Phase Difference 35 Degrees with Noise)**			
Result(Scope Corder) **Result(ELCS/PICS data)**		**Acceptance Criteria**	**Judgment**
Item	**Time**		
The time when the first SCRAM is generated (Discrete)	20 : 34 : 46	First "SCRAM" signal (Discrete) is generated within +/- 2s of "OPRM Trip" signal (ELCS/PICS data).	Sat.
The time when the first OPRMTrip is generated (Optical)	20 : 34 : 45		
The time when the first PBDA_TRIP is generated (Discrete)	20 : 34 : 46	The first "PBDA_TRIP" signal (Discrete) is generated within +/- 2s of "PBDA Trip" signal (ELCS/PICS data).	Sat.
The time when the first PBDA Trip is generated (Optical)	20 : 34 : 45	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Sat.
The time when the first GRA_TRIP is generated (Discrete)	20 : 35 : 20	The first "GRA_TRIP" signal (Discrete) is generated within +/- 2s of "GRA Trip" signal (ELCS/PICS data).	Sat.
The time when the first GRA Trip is generated (Optical)	20 : 35 : 19	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Sat.
The time when the first ABA_TRIP is generated (Discrete)	20 : 35 : 35	The first "ABA_TRIP" signal (Discrete) is generated within +/- 2s of "ABA Trip" signal (ELCS/PICS data).	Sat.
The time when the first ABA Trip is generated (Optical)	20 : 35 : 35	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.	Sat.

3.2 Software Validation Test (18 of 30)			
3.2.3 Additional Validation of Trip Algorithms **3.2.3.6 Test Pattern 6 (Cell 38 Frequency 0.45Hz Phase Difference 35 Degrees with Noise)**			
Result(PC data)		**Acceptance Criteria**	**Judgment**
Item	**Time**		
The time when the first OPRMTrip is generated (Optical)	20 : 34 : 45		
The time when the first PBDA Trip is generated (Optical)	20 : 34 : 45	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Sat.
The time when the first GRA Trip is generated (Optical)	20 : 35 : 19	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Sat.
The time when the first ABA Trip is generated (Optical)	20 : 35 : 35	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.	Sat.

7. Test Pattern 7

(1) Explanation of Test Item

The same test pattern files as that used for Test Pattern 1 (Cell2, frequency [ ]$^{a, c}$ Hz) are used. To check trip algorithms when signals of LPRM A and LPRM B are bypassed, transmission of LPRM unit 1 data and LPRM unit 4 data is stopped manually.

Acceptance criteria:

Status of discrete outputs, ELCS [ ]$^{a, c}$ data outputs and PC data outputs are as expected in Table 10-2.

(2) Test Result

3.2 Software Validation Test (20 of 30)			
3.2.3 Additional Validation of Trip Algorithms 3.2.3.7 Test Pattern 7 (Cell 2 Frequency 0.20Hz Phase Difference 35 Degrees with LPRM A and LPRM B Bypass))			
Result(Scope Corder) Result(ELCS/PICS data)		Acceptance Criteria	Judgment
Item	Time		
The time when the first SCRAM is generated (Discrete)	20 : 56 : 30	First "SCRAM" signal (Discrete) is generated within +/- 2s of "OPRM Trip" signal (ELCS/PICS data).	Sat.
The time when the first OPRMTrip is generated (Optical)	20 : 56 : 29		
The time when the first PBDA_TRIP is generated (Discrete)	20 : 56 : 30	The first "PBDA_TRIP" signal (Discrete) is generated within +/- 2s of "PBDA Trip" signal (ELCS/PICS data).	Sat.
The time when the first PBDA Trip is generated (Optical)	20 : 56 : 30	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Sat.
The time when the first GRA_TRIP is generated (Discrete)	20 : 57 : 47	The first "GRA_TRIP" signal (Discrete) is generated within +/- 2s of "GRA Trip" signal (ELCS/PICS data).	Sat.
The time when the first GRA Trip is generated (Optical)	20 : 57 : 46	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Sat.
The time when the first ABA_TRIP is generated (Discrete)	20 : 58 : 17	The first "ABA_TRIP" signal (Discrete) is generated within +/- 2s of "ABA Trip" signal (ELCS/PICS data).	Sat.
The time when the first ABA Trip is generated (Optical)	20 : 58 : 16	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.	Sat.

3.2 Software Validation Test (21 of 30)			
3.2.3 Additional Validation of Trip Algorithms 3.2.3.7 Test Pattern 7 (Cell 2 Frequency 0.20Hz Phase Difference 35 Degrees with LPRM A and LPRM B Bypass))			
Result(PC data)		Acceptance Criteria	Judgment
Item	Time		
The time when the first OPRMTrip is generated (Optical)	20 : 56 : 29		
The time when the first PBDA Trip is generated (Optical)	20 : 56 : 30	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Sat.
The time when the first GRA Trip is generated (Optical)	20 : 57 : 46	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Sat.
The time when the first ABA Trip is generated (Optical)	20 : 58 : 16	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.	Sat.

8. Test Pattern 8

(1) Explanation of Test Item

The same test pattern files as that used for Test Pattern 2 (Cell20, frequency [ ]a, c Hz) are used. To check trip algorithms when signals of LPRM A and LPRM B are bypassed, transmission of LPRM unit 2 data and LPRM unit 3 data is stopped manually.

Acceptance criteria:

Status of discrete outputs, ELCS/[ ]a, c data outputs and PC data outputs are as expected in Table 10-2.

(2) Test Result

3.2 Software Validation Test			(23 of 30)
3.2.3 Additional Validation of Trip Algorithms 3.2.3.8 Test Pattern 8 (Cell 20 Frequency 0.45Hz Phase Difference 35 Degrees with LPRM A and LPRM B Bypass))			
Result(Scope Corder) Result(ELCS/PICS data)		**Acceptance Criteria**	**Judgment**
Item	**Time**		
The time when the first SCRAM is generated (Discrete)	21 : 15 : 47	First "SCRAM" signal (Discrete) is generated within +/- 2s of "OPRM Trip" signal (ELCS/PICS data).	Sat.
The time when the first OPRMTrip is generated (Optical)	21 : 15 : 47		
The time when the first PBDA_TRIP is generated (Discrete)	21 : 15 : 47	The first "PBDA_TRIP" signal (Discrete) is generated within +/- 2s of "PBDA Trip" signal (ELCS/PICS data).	Sat.
The time when the first PBDA Trip is generated (Optical)	21 : 15 : 47	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Sat.
The time when the first GRA_TRIP is generated (Discrete)	21 : 16 : 21	The first "GRA_TRIP" signal (Discrete) is generated within +/- 2s of "GRA Trip" signal (ELCS/PICS data).	Sat.
The time when the first GRA Trip is generated (Optical)	21 : 16 : 21	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Sat.
The time when the first ABA_TRIP is generated (Discrete)	21 : 16 : 37	The first "ABA_TRIP" signal (Discrete) is generated within +/- 2s of "ABA Trip" signal (ELCS/PICS data).	Sat.
The time when the first ABA Trip is generated (Optical)	21 : 16 : 36	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.	Sat.

3.2 Software Validation Test			(24 of 30)
3.2.3 Additional Validation of Trip Algorithms 3.2.3.8 Test Pattern 8 (Cell 20 Frequency 0.45Hz Phase Difference 35 Degrees with LPRM A and LPRM B Bypass))			
Result(PC data)		**Acceptance Criteria**	**Judgment**
Item	**Time**		
The time when the first OPRMTrip is generated (Optical)	21 : 15 : 47		
The time when the first PBDA Trip is generated (Optical)	21 : 15 : 47	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Sat.
The time when the first GRA Trip is generated (Optical)	21 : 16 : 21	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Sat.
The time when the first ABA Trip is generated (Optical)	21 : 16 : 36	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.	Sat.

9. Test Pattern 9

(1) Explanation of Test Item

The same test pattern files as that used for Test Pattern 3 (Cell22, frequency [ ]$^{a, c}$ Hz) are used. To check trip algorithms when signals of LPRM A and LPRM B are bypassed, transmission of LPRM unit 1 data and LPRM unit 3 data is stopped manually.

Acceptance criteria:

Status of discrete outputs, ELCS [ ]$^{a, c}$ data outputs and PC data outputs are as expected in Table 10-2.

(2) Test Result

3.2 Software Validation Test (26 of 30)			
3.2.3 Additional Validation of Trip Algorithms 3.2.3.9 Test Pattern 9 (Cell 22 Frequency 0.70Hz Phase Difference 35 Degrees with LPRM A and LPRM B Bypass))			
Result(Scope Corder) Result(ELCS/PICS data)		**Acceptance Criteria**	**Judgment**
Item	**Time**		
The time when the first SCRAM is generated (Discrete)	21 : 28 : 14	First "SCRAM" signal (Discrete) is generated within +/- 2s of "OPRM Trip" signal (ELCS/PICS data).	Sat.
The time when the first OPRMTrip is generated (Optical)	21 : 28 : 13		
The time when the first PBDA_TRIP is generated (Discrete)	21 : 28 : 14	The first "PBDA_TRIP" signal (Discrete) is generated within +/- 2s of "PBDA Trip" signal (ELCS/PICS data).	Sat.
The time when the first PBDA Trip is generated (Optical)	21 : 28 : 13	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Sat.
The time when the first GRA_TRIP is generated (Discrete)	21 : 28 : 36	The first "GRA_TRIP" signal (Discrete) is generated within +/- 2s of "GRA Trip" signal (ELCS/PICS data).	Sat.
The time when the first GRA Trip is generated (Optical)	21 : 28 : 35	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Sat.
The time when the first ABA_TRIP is generated (Discrete)	21 : 28 : 48	The first "ABA_TRIP" signal (Discrete) is generated within +/- 2s of "ABA Trip" signal (ELCS/PICS data).	Sat.
The time when the first ABA Trip is generated (Optical)	21 : 28 : 47	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.	Sat.

3.2 Software Validation Test (27 of 30)			
3.2.3 Additional Validation of Trip Algorithms 3.2.3.9 Test Pattern 9 (Cell 22 Frequency 0.70Hz Phase Difference 35 Degrees with LPRM A and LPRM B Bypass))			
Result(PC data)		**Acceptance Criteria**	**Judgment**
Item	**Time**		
The time when the first OPRMTrip is generated (Optical)	21 : 28 : 13		
The time when the first PBDA Trip is generated (Optical)	21 : 28 : 13	The first "PBDA Trip" signal is generated after the NOS exceeds the threshold level (Sp=1.10) for the first time.	Sat.
The time when the first GRA Trip is generated (Optical)	21 : 28 : 35	The first "GRA Trip" signal is generated after the NOS exceeds the threshold level (S1=1.20) for the second time.	Sat.
The time when the first ABA Trip is generated (Optical)	21 : 28 : 47	The first "ABA Trip" signal is generated after the NOS exceeds the threshold level (Smax=1.30) for the first time.	Sat.

10. Test Pattern 10

(1) Explanation of Test Item

The same test pattern files as that used for Test Pattern 1 (Cell2, frequency [ ]a, c Hz) are used. It is checked that trip signals are not generated when the setpoints of Th and Tmax are changed from the "Standard Settings."

Acceptance criteria:

Status of discrete outputs, ELCS [ ]a, c data outputs and PC data outputs are as expected in Table 10-2.

(2) Test Result

3.2 Software Validation Test			(29 of 30)
3.2.3 Additional Validation of Trip Algorithms 3.2.3.10 Test Pattern 10 (Cell 2 Frequency 0.45Hz Phase Difference 35 with Initial Parameters of Th and Tmax)			
Result(Scope Corder) Result(ELCS/PICS data)		Acceptance Criteria	Judgment
Item	Status		
The time when the first SCRAM is generated (Discrete)	☑Not generated ☐Generated	Not generated	Sat.
The time when the first OPRMTrip is generated (Optical)	☑Not generated ☐Generated	Not generated	Sat.
The time when the first PBDA_TRIP is generated (Discrete)	☑Not generated ☐Generated	Not generated	Sat.
The time when the first PBDA Trip is generated (Optical)	☑Not generated ☐Generated	Not generated	Sat.
The time when the first GRA_TRIP is generated (Discrete)	☑Not generated ☐Generated	Not generated	Sat.
The time when the first GRA Trip is generated (Optical)	☑Not generated ☐Generated	Not generated	Sat.
The time when the first ABA_TRIP is generated (Discrete)	☑Not generated ☐Generated	Not generated	Sat.
The time when the first ABA Trip is generated (Optical)	☑Not generated ☐Generated	Not generated	Sat.

3.2 Software Validation Test			(30 of 30)
3.2.3 Additional Validation of Trip Algorithms 3.2.3.10 Test Pattern 10 (Cell 2 Frequency 0.45Hz Phase Difference 35 with Initial Parameters of Th and Tmax)			
Result(PC data)		Acceptance Criteria	Judgment
Item	Status		
The time when the first OPRMTrip is generated (Optical)	☑Not generated ☐Generated	Not generated	Sat.
The time when the first PBDA Trip is generated (Optical)	☑Not generated ☐Generated	Not generated	Sat.
The time when the first GRA Trip is generated (Optical)	☑Not generated ☐Generated	Not generated	Sat.
The time when the first ABA Trip is generated (Optical)	☑Not generated ☐Generated	Not generated	Sat.

11. Test Anomaly Reporting for Additional Validation

Test anomaly was not found in the additional system validation testing.

12. Conclusion

The NICSD IV&V Team concluded that the software validation test in the system validation testing was performed in a correct manner, and all the test result satisfied the acceptance criteria specified in the SVTP (Reference (14)).

The NICSD IV&V Team concluded that the software validation test in the additional system validation testing was performed in a correct manner, and all the test result satisfied the acceptance criteria specified in the SVTP for Additional Validation (Reference (20)).